BUILDING BACK THE U.S. RESEARCH ENTERPRISE: COVID IMPACTS AND RECOVERY

HEARING

BEFORE THE

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February 25, 2021

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BUILDING BACK THE U.S. RESEARCH ENTERPRISE: COVID IMPACTS AND RECOVERY

THURSDAY, FEBRUARY 25, 2021

HOUSE OF REPRESENTATIVES,
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Committee met, pursuant to notice, at 10:01 a.m., via Webex, Hon. Eddie Bernice Johnson [Chairwoman of the Committee] presiding.

U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
HEARING CHARTER

Building Back the U.S. Research Enterprise: COVID Impacts and Recovery

Thursday, February 25, 2021
10:00 am – 12:00 pm ET
Cisco WebEx

PURPOSE

The purpose of this hearing is to assess the near- and long-term impacts of the COVID-19 health crisis on the U.S. science and innovation enterprise. The Committee will examine the steps taken to mitigate the spread of the virus and the consequences for research production, the pipeline of STEM talent, and U.S. economic competitiveness. The hearing is also an opportunity for Members to explore what is needed to recover from these setbacks and ensure the U.S. maintains its leadership role in science and innovation. This hearing is also an opportunity for the Committee to hear testimony on the *Research Investment to Spark the Economy (RISE) Act* and *the Supporting Early-Career Researchers Act.*

WITNESSES

- **Dr. Sudip Parikh**, Chief Executive Officer, American Association for the Advancement of Science
- **Dr. Christopher Keane**, Vice President for Research, Washington State University
- **Dr. Felice J. Levine**, Executive Director, American Educational Research Association
- **Mr. Thomas Quaadman**, Executive Vice President, Center for Capital Markets Competitiveness, U.S. Chamber of Commerce

KEY QUESTIONS

- What challenges has the research community faced in continuing research activities during the coronavirus pandemic?
- How has the COVID-19 crisis affected undergraduate students transitioning into STEM graduate programs and recent Ph.D. graduates entering the academic and private sector job market?
- In what ways, if any, are these challenges disproportionately affecting women, individuals from underrepresented minority groups, and international students?
- What are the implications of the potential loss of talent for the U.S. research and innovation ecosystem and economic competitiveness?
- What actions can the Federal Government take to help the research community recover from setbacks due to the COVID-19 crisis, ramp up research programs, and mitigate the loss of STEM talent?
- In what ways has the COVID-19 health crisis helped to catalyze and accelerate research and innovation? What actions can the Federal Government take to support these activities?

U.S. RESEARCH ENTERPRISE

The research enterprise in the United States is a complex, interconnected, and dynamic system, with the private sector, the Federal Government, universities, and nonprofit organizations all playing complementary roles. Businesses perform and fund most of the overall research and development (R&D) in the U.S. With a focus on new and improved goods, services, and processes, businesses dominate in performing and funding both applied research[1] and experimental development.[2] With a focus on generating new knowledge, fulfilling agency missions, and training a skilled workforce, the Federal Government funds the second largest share of R&D and the largest share of basic research.[3] Universities are the largest performer of basic research. The Federal Government also plays a unique role in supporting high-risk research with long-term benefits to society. In the Federal Government, six agencies provide the most support for R&D:

- Department of Defense (38%, or $44.9 billion)
- Department of Health and Human Services (28%, or $33.8 billion)
- National Aeronautics and Space Administration (11%, or $12.6 billion)
- Department of Energy (10%, or $12.3 billion)
- National Science Foundation (5%, or $5.5 billion)
- Department of Agriculture (2%, or $2.4 billion) [4]

Although competition with other nations, particularly China, has intensified in recent years, the U.S. research enterprise "continues to perform the largest share of global research and development (R&D), generate the largest share of R&D-intensive industry output globally, award the largest number of science and engineering (S&E) doctoral degrees, and account for significant shares of S&E research articles and citations worldwide".[5]

COVID IMPACT ON U.S. R&D

The coronavirus outbreak has caused major disruptions to the research enterprise. The White House imposed restrictions on travel from China on February 2, 2020 and Europe on March 13, 2020. On March 16, 2020, the White House issued guidelines[6] restricting gatherings of more than 10 people. On March 19, California was the first state to issue a state-wide stay-at-home order. By early April, more than 300 million

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[1] Applied research is an "Original investigation undertaken in order to acquire new knowledge." and is "directed primarily towards a specific practical aim or objective." Source: OMB Circular A-11. Available at https://www.whitehouse.gov/wp-content/uploads/2018/06/a11.pdf

[2] Experimental development is "Creative and systematic work, drawing on knowledge gained from research and practical experience, which is directed at producing new products or processes or improving existing products or processes." Source: OMB Circular A-11. Available at https://www.whitehouse.gov/wp-content/uploads/2018/06/a11.pdf

[3] Basic research is "experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts." Source: OMB Circular A-11. Available at https://www.whitehouse.gov/wp-content/uploads/2018/06/a11.pdf

[4] National Science Board, Science and Engineering Indicators 2020, Available at https://ncses.nsf.gov/pubs/nsb20202/.

[5] National Science Board, Science and Engineering Indicators 2020, Available at https://ncses.nsf.gov/pubs/nsb20201/executive-summary

[6] The White House, The President's Coronavirus Guidelines for America: 30 Days to Slow the Spread, Available at https://www.whitehouse.gov/wp-content/uploads/2020/03/03.16.20_coronavirus-guidance_8.5x11_315PM.pdf.

Americans were under directives to "shelter-in-place" or "stay-at-home". As case numbers increased during the second wave of the outbreak during the summer, state plans to reopen were halted or scaled back. And now, as cases decline during the third wave of the outbreak, there is a nationwide patchwork of restrictions that reflects months of trial and error, with an emphasis on capacity limits, social distancing, and mandating mask use in public.

Measures taken to comply with social distancing restrictions created major disruptions at research universities across the country. While there is extensive discussion in the news and among policymakers about the status of in-person education and the related challenges unfolding on and around university campuses across the country, this hearing is focused on impacts on the research enterprise.

Impact on Research Production

The ability of faculty researchers to continue to make progress on their research remotely depends, in part, on the nature of the project and their discipline. For example, researchers working remotely may be able to perform certain tasks like scientific computations, modeling and simulation, experimental hardware design, data analysis, and drafting journal articles. In contrast, handling physical and biological samples, caring for laboratory animals, and building or operating specialized equipment require a researcher to be present in the laboratory. Research involving human subjects may be interrupted if those subjects are unavailable because of social distancing. In some cases, the extent to which research activities can continue may depend on the duration of the disruption; many researchers may have pivoted toward analyzing data and writing up findings for publication – tasks they can do from home - but eventually they will have run out of new data to analyze. Travel restrictions have impeded research across all disciplines for scientists who engage in field observation work. Data sets that require months or even years of regular observations now have an irreversible break in continuity.

COVID mitigation restrictions have forced scientific societies to cancel or move conferences online. A scientific conference is not just an avenue for a scientist to present their research to the wider community, it is also an important venue for brainstorming, networking, and developing new collaborations. Conference cancellations also cut off a major source revenue for scientific societies, putting the societies and the vital role they play at risk. While some are optimistic that virtual conferences could add value in the long run, such a radically new model will take time to perfect.

Another factor affecting research production is the closure of research facilities. While reducing staffing to maintain social distancing may be an option at some research facilities—such as telescopes or environmental sensor networks that share data with researchers remotely—other facilities require intensive on-site personnel for maintenance and operation. Closures of R&D facilities depend on the independent decisions of individual agencies, universities, and other institutions. For example, the National Aeronautics and Space Administration (NASA) decides the status of each of its centers separately, based on local conditions, according to a four-stage response framework.[7] Actions by state or local governments also factor into the decisions of some facilities. For example, shutdowns at Department of Energy (DOE) laboratories in California and Illinois followed statewide social distancing orders issued by the governors of

[7] https://nasapeople.nasa.gov/coronavirus/nasa_response_framework.pdf

those states.[8] Managing organizations and contractors operating National Science Foundation (NSF) facilities also consider local conditions and statewide orders in making operational decisions.[9]

The Council on Governmental Relations, an association of almost 200 U.S. universities and research institutes, recently released a report presenting a model for estimating research output loss and quantifying the financial impacts of the COVID-19 pandemic on research activities. The model is designed to account for factors such as reduced work, lost laboratory supplies, and inability to travel under differing impact and recovery scenarios. The report uses five case studies to illustrate the state of research under what it terms the new "pandemic normal," and projects research output losses between March 2020 and February 2021 at individual institutions ranging between 20% and 40% and a financial impact in the hundreds of millions of dollars. The report also projects a potential impact in the tens of billions of dollars across the U.S. research enterprise.[10] In the case of the National Institutes of Health (NIH), Director Francis Collins, while testifying before Congress on May 7, 2020 stated, "The estimates are something like $10 billion of NIH funded-research that is going to disappear because of the way in which this virus has affected everybody requiring this kind of distancing and sending people home."[11]

Impact on People

Across the board, campus closures and social distancing requirements have significantly altered how researchers do their work. Researchers forced to work remotely or under stringent social distancing requirements are experiencing significant delays in achieving their research aims. Students are also experiencing reduced access to professional development, networking, and hands-on training. For students, postdocs, and junior faculty, disruptions caused by the COVID crisis come at a critical juncture in their career and may have long-lasting impacts.

For example, many undergraduate students would normally have spent the summer months developing research skills through summer research internships. These programs offer students valuable research experience beyond their classroom studies and have a strong influence on student career aspirations. As a result of summer research internships being canceled, many students in their final year will not have the research experience necessary to prepare a competitive application to a graduate research program. The switch to remote classes has also made it difficult for students to fulfill their degree requirements, in particular due to the unavailability of required laboratory-based courses.

Many graduate students are struggling to complete their projects on time and publish enough papers to be competitive for postdoctoral fellowships or research positions in industry. Graduate students are also missing out on important networking and collaboration opportunities as conferences have gone all virtual. The cumulative effect of these challenges is taking its toll on graduate student mental health. A recent survey of undergraduate and graduate students at 10 U.S. research universities found that signs of depression doubled among graduate students when compared with a similar survey from last year. Indications of anxiety among graduate students increased by 50% during the same period. Rates of mental

[8] https://www.aip.org/fyi/2020/pandemic-impacts-escalating-across-federal-labs
[9] https://www.nsf.gov/news/special_reports/coronavirus/NSF%20Guidance%20for%20Major%20Facilities%20and%20Contracts%20Regarding%20COVID-19.pdf
[10] https://www.cogr.edu/sites/default/files/Research_COVID_August2020_COGR_FINAL.pdf
[11] https://news.bloomberglaw.com/pharma-and-life-sciences/virus-will-cost-nih-10-billion-in-lost-research-director-warns

distress were particularly high among low-income, Latinx, and LGBTQ students and those working in physical and biomedical sciences.[12]

The impacts of the COVID crisis on academic employment may be long-lasting. Faced with reduced revenue and unanticipated costs related to the pandemic, institutions have been forced to withdraw job offers, furlough and lay off workers, and implement hiring freezes. According to a recent analysis by *Science* magazine, faculty job openings at U.S. institutions were down by 70% in October 2020.[13] Hiring freezes in academia have substantially reduced the job prospects for early-career scientists in particular. Those failing to find an academic position are faced with the difficult decision to abandon their career goals in order to support themselves and their families. This potentially irreversible loss of talent from the research pipeline could have lasting negative consequences for U.S. innovation and economic competitiveness.

Another key factor in the ability of a researcher to be productive in carrying out their research remotely is childcare. Early analyses of submissions of draft research papers to pre-print servers suggest that the pandemic is disproportionately affecting female academics, because women often do more caregiving than men.[14,15] For example, a recent survey of approximately 4,500 Principal Investigators (PIs) at U.S. and European research institutions found that "scientists report a sharp decline in time spent on research on average, but there is substantial heterogeneity with a significant share reporting no change or even increases. Some of this heterogeneity is due to field-specific differences, with laboratory-based fields being the most negatively affected, and some is due to gender, with female scientists reporting larger declines. However, among the individuals' characteristics examined, the largest disruptions are connected to childcare. Reporting a young dependent is associated with declines similar in magnitude to those reported by the laboratory-based fields and can account for a significant fraction of gender differences."[16]

International students are also experiencing major disruptions to their research careers. The impact of travel restrictions has been particularly severe for these students. A recent Institute of International Education (IIE) report found a 43 percent drop in new international student enrollment for U.S. institutions during the Fall 2020 term.[17] Foreign students play a critical role in university research labs, and many remain in the United States after graduation and continue to contribute to our leadership in science and technology.[18]

COVID RECOVERY NEEDS

Last year, the Office of Management and Budget (OMB), in collaboration with federal science agencies, provided temporary administrative and salary charging flexibilities to protect against furloughs and layoffs. Agencies provided guidance for universities and offered no-cost extensions[19] to the term of current research grants to make up for time lost. Some agencies also extended the deadline dates for a few solicitations to give PIs more time to submit proposals or have been lenient with PIs who miss a deadline. As of September 30, 2020, however, all OMB memoranda for administrative flexibilities have expired.[20]

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[12] https://escholarship.org/uc/item/80k5d5hw
[13] https://www.sciencemag.org/careers/2020/10/amid-pandemic-us-faculty-job-openings-plummet
[14] https://www.nature.com/articles/d41586-020-01294-9
[15] https://www.nature.com/articles/d41586-020-02183-x
[16] https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3608302
[17] file:///C:/Users/sdb/AppData/Local/Temp/Fall%202020%20Snapshot%20Report%20-%20Full%20Report.pdf
[18] https://www.nsf.gov/nsb/sci/one-pagers/Foreign-Born.pdf
[19] A no-cost extension extends the end date of the award without increasing funding.
[20] https://www.whitehouse.gov/wp-content/uploads/2020/06/M-20-26.pdf

While the *CARES Act*[21] provided some funding to Federal research agencies, the funding amounts fell short of the need. Significant additional federal support (through supplements and full-cost extensions[22] to existing grants, administrative flexibility, or other mechanisms) is needed to enable the U.S. research enterprise to recover after a prolonged period of profound disruption. Additional funding to support graduate students and post-doctoral researchers whose research and training have been interrupted or otherwise delayed due to the pandemic is also critical to prevent a significant loss of talent from the STEM pipeline. In January 2021, organizations representing research universities, medical schools, and teaching hospitals asked Congress to provide $26 billion in additional extramural research funding in the next pandemic recovery package.[23]

LEGISLATION

RISE Act

The *Research Investment to Spark the Economy (RISE) Act* (H.R. 869) authorizes approximately $25 billion in emergency relief across federal science agencies to award to universities and national laboratories to continue working on federally-funded research projects and ensure that years of research – and the researchers that makes it possible - are not lost forever due to the pandemic.[24, 25]

Supporting Early-Career Researchers Act

The *Supporting Early-Career Researchers Act* (H.R. 144) creates a new $250 million postdoctoral fellowship program at the National Science Foundation to support career development for early-career researchers whose employment opportunities have been impacted by the COVID-19 crisis. NSF estimates that a program established under this Act would support about 1,600 fellows.[26, 27, 28]

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[21] https://www.congress.gov/bill/116th-congress/house-bill/748/text
[22] A full-cost extension extends the end date of the award and provides additional funding to cover the costs to complete the activities.
[23] https://www.aplu.org/members/councils/governmental-affairs/CGA-library/association-letter-covid-19-research-relief-letter/file
[24] https://www.congress.gov/bill/117th-congress/house-bill/869?s=1&r=1
[25] https://degette.house.gov/media-center/press-releases/lawmakers-introduce-bipartisan-plan-to-provide-us-researchers-25-billion
[26] https://www.congress.gov/bill/117th-congress/house-bill/144
[27] https://science.house.gov/news/press-releases/chairwoman-johnson-and-ranking-member-lucas-introduce-legislation-to-support-early-career-researchers-during-and-after-pandemic
[28] In fiscal year 2019, NSF supported 5,320 postdoctoral associates through funds included in research projects, centers, or facilities awards, as well as by postdoctoral fellowships. https://www.nsf.gov/about/budget/fy2021/pdf/fy2021budget.pdf

Chairwoman JOHNSON. And without objection, the Chair is authorized to declare recess at any time.

Pursuant to *House Resolution 8*, today, the Committee is meeting virtually. I want to announce a couple of reminders to the Members about the conduct of the remote hearing. First, Members should keep their video feed on as long as they are present in the hearing, and Members are responsible for their own microphones. Please keep your microphones muted until you are speaking. And finally, if Members have documents they wish to submit for the record, please email them to the Committee Clerk, whose email address was circulated prior to the meeting.

Good morning and welcome to today's hearing. I want to thank our distinguished panel for joining us today and remind them that there are probably two of the names that I'll get a little bit mixed because I'm from Waco, Texas, and I only speak Waco English. But I want to thank our distinguished panel for joining us today.

This week our Nation passed yet another heart-wrenching milestone. More than a half million of our friends, neighbors, family members, frontline workers, and fellow citizens have succumbed to COVID–19 since the disease first touched our shores a little more than a year ago. Even as vaccines are being administered around the country, help has come too late for them and for the more than 2,000 Americans who continue to die each passing day. Those numbers are staggering, yet we must remember it would have been even worse if not for the sacrifices that Americans have been making to bring this virus under control.

The necessary mitigation measures undertaken by individuals and by businesses, institutions, and organizations of all types have created enormous disruptions to every sector of American life, including agriculture, manufacturing, hospitality, education, sports, transportation, and health care as we have attempted to slow this deadly spread of the virus. Scientific research has not been spared.

We are here today to discuss the state of the U.S. research enterprise one year into this pandemic, and to explore what is needed to get things back on track. For my colleagues who are new to the Committee, let me say a few words about the critical role research plays in our society. For decades, federally funded research has generated new ideas and spurred breakthrough innovations, which fuel our economy and create jobs, inspire new generations of young people to pursue science, improve public health and education, and keep us a step ahead of our global competitors. Our research system is the envy of the world, and many nations have tried hard to emulate it.

In this hearing we will examine the ways in which the pandemic has slowed the pace of research and innovation and reversed hard-earned gains in expanding our STEM (science, technology, engineering, and math) workforce. I am deeply concerned about the long-term consequences for the American people if we don't make these investments necessary to address the needs of our science agencies, universities, researchers, and students.

Even before the pandemic, years of stagnant funding dramatically eroded our standing as the leader in science and innovation with countries like China nipping at our heels. It is not enough to recover simply to maintain the status quo. We must grow the re-

search enterprise so that we can boldly tackle the urgent challenges ahead of us.

For these reasons, I did not hesitate to join my bipartisan colleagues in the House in cosponsoring the *RISE Act*. I was also pleased to be joined by Ranking Member Lucas in reintroducing the *Supporting Early Career Researchers Act*, which is focused specifically on keeping the best and brightest in research careers that they have already worked so hard for. I hope my colleagues on both sides of the aisle will continue to join me in advocating for their passage and the real funding for those two bills.

In that regard, I look forward to learning from the expert panel about the specific challenges and needs one year into the pandemic, including any recommendations for updating these bills. Well, we have a lot to consider today, and I again want to thank our witnesses for appearing with us today.

[The prepared statement of Chairwoman Johnson follows:]

Good morning and welcome to today's hearing. I want to thank our distinguished panel for joining us today. This week our Nation passed yet another heart wrenching milestone. More than half a million of our friends, neighbors, family members, front-line workers, and fellow citizens have succumbed to COVID-19 since the disease first touched our shores a little over one year ago. Even as vaccines are being administered around the country, help has come too late for them and the more than two thousand Americans who continue to die with each passing day.

Those numbers are staggering, yet we must remember it would have been even worse if not for the sacrifices Americans have been making to bring the virus under control. The necessary mitigation measures undertaken by individuals and by businesses, institutions, and organizations of all types have created enormous disruptions to every sector of American life, including agriculture, manufacturing, hospitality, education, sports, transportation, and health care as we have attempted to slow the deadly spread of the virus. Scientific research has not been spared.

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In this hearing we will examine the ways in which the pandemic has slowed the pace of research and innovation and reversed hard-earned gains in expanding our STEM workforce. I am deeply concerned about the long-term consequences for the American people if we don't make the investments necessary to address the needs of our science agencies, universities, researchers, and students. Even before the pandemic, years of stagnant funding dramatically eroded our standing as the leader in science and innovation, with countries like China nipping at our heels. It is not enough to recover simply to maintain the status quo-we must grow the research enterprise so we can boldly tackle the urgent challenges ahead of us.

For those reasons, I did not hesitate to join my bipartisan colleagues in the House in cosponsoring the *RISE Act*. I was also pleased to be joined by Ranking Member Lucas in re-introducing the *Supporting Early Career Researchers Act*, which is focused specifically on keeping the best and brightest in research careers that they have already worked so hard for. I hope my colleagues on both sides of the aisle will continue to join me in advocating for their passage and for real funding for those two bills. In that regard, I look forward to learning from the expert panel about the specific challenges and needs one year into the pandemic, including any recommendations for updating those bills.

Well, we have a lot to consider today, and I again want to thank our witnesses for appearing before us today.

I now yield to Ranking Member Lucas for his opening statement.

Chairwoman JOHNSON. Before I recognize Mr. Lucas for the—his opening remarks, I'd like to present for the record a report from

the American Physical Society entitled "Issue Brief: The U.S. R&D Community Pandemic Recovery Lagging."

Thank you. And now I will ask for Mr. Lucas for his opening statement.

Mr. LUCAS. Thank you, Chairwoman Johnson, both for being a pleasure to work with and for holding this hearing. I believe that today's topics, restarting American research, is one of the most important issues we face at this moment. In September we heard from students and academics about the far-reaching impacts of COVID shutdowns. Those problems are only getting worse as Congress continues to ignore this problem in COVID relief bills. American research universities support nearly 7 million jobs, and hundreds of thousands of those are directly supported by research funding. As research funding dries, those jobs are threatened.

The research itself is also suffering. When COVID hit, labs across the country had to close or dramatically limit their operations to provide for safe social distancing. It's estimated we're losing between 20 and 40 percent of our research output, which we absolutely cannot afford if we want to keep pace with China.

The Chinese Communist Party is determined to overtake us in the industries of the future, areas of science and technology that will drive economic growth and national security in the years to come. The longer our research remains stalled, the more likely it is we'll fall behind our foreign adversaries on technologies like artificial intelligence, quantum information sciences and advanced manufacturing. The consequences of that would be devastating.

In addition to our loss of research, we're facing the loss of our researchers. Graduate students and post-docs are particularly vulnerable to lab closures right now. Research interruptions make it difficult to complete their studies and graduate on time. And universities have instituted hiring freezes, making it difficult to find work. Our STEM pipeline and future competitiveness could be irreparably damaged if we don't act quickly.

Unfortunately, we can't just flip a switch and restart the research work that's been halted by the pandemic. There's a cost involved in getting back up and running. Scientists need to cultivate new samples; field researchers need to reacquire equipment, permits, and tools; and labs need to figure out how to safely use and sterilize expensive and delicate equipment.

For a time, research will cost more and take longer to conduct. We need to plan for that. But our science progress is worth that investment. That's why I was so disappointed that in the $4 trillion in COVID spending that Congress has already passed, not one cent has gone to research itself. In the massive and partisan $1.9 trillion budget reconciliation proposal being considered this week, billions and billions of dollars are going to special interests that already have $1 trillion in unspent funding sitting in the Treasury from previous COVID packages. And yet in all that spending, only $600 million was allocated to helping the research industry recover from the pandemic. That's less than half a percent.

We've relied on American science and scientists to combat COVID, but we're not giving them the funding they need to resume the work that's been stopped by the pandemic. We need to act now.

I'm a proud cosponsor of the *RISE Act*, which would invest $25 billion in restarting American research. It provides the funding needed for researchers to complete work that was halted due to the pandemic. And it will allow Federal science agencies to make awards to research universities, independent institutions, and national laboratories.

I'm also proud of the *Supporting Early Career Researchers Act* Chairwoman Johnson and I reintroduced at the start of this Congress. This bill creates a new postdoctoral fellowship program at the National Science Foundation to help support early career researchers.

Both of these bills enjoy strong bipartisan support, which is why I'm hopeful that we can move forward on them sooner rather than later. In the meantime, I'd like to thank our witnesses for being here today. I'm looking forward to learning more about the challenges facing our research industry and to hear your ideas about how we can support American scientists and technology.

And with that, Madam Chair, again, thank you. And I yield back.

[The prepared statement of Mr. Lucas follows:]

Thank you, Chairwoman Johnson, for holding this hearing. I believe that today's topic—restarting American research—is one of the most important issues we face at this moment. In September we heard from students and academics about the far-ranging impacts of COVID shutdowns. Those problems are only getting worse as Congress continues to ignore this problem in COVID relief bills.

American research universities support nearly 7 million jobs, and hundreds of thousands of those are directly supported by research funding. As research funding dries up, those jobs are threatened.

The research itself is also suffering. When COVID hit, labs across the country had to close or dramatically limit their operations to provide for safe social distancing. It's estimated that we're losing between 20 and 40 percent of our research output, which we absolutely cannot afford if we want to keep pace with China.

The Chinese Communist Party is determined to overtake us in the industries of the future-areas of science and technology that will drive economic growth and national security in the years to come. The longer our research remains stalled, the more likely it is that we'll fall behind our foreign adversaries on technologies like artificial intelligence, quantum information sciences, advanced manufacturing. The consequences of that would be devastating.

In addition to our loss of research, we're facing the loss of our researchers. Graduate students and post-docs are particularly vulnerable to lab closures right now. Research interruptions make it difficult to complete their studies and graduate on time. And universities have instituted hiring freezes, making it difficult to find work. Our STEM pipeline and future competitiveness could be irreparably damaged if we don't act quickly.

Unfortunately, we can't just flip a switch and restart the research work that's been halted by the pandemic. There's a cost involved in getting back up and running. Scientists need to cultivate new samples, field researchers need to reacquire equipment, permits, and tools, and labs need to figure out how to safely use and sterilize expensive and delicate equipment.

For a time, research will cost more and take longer to conduct, and we need to plan for that. But our scientific progress is worth that investment. That's why I'm so disappointed that in the $4 trillion in COVID spending that Congress has already passed, not one cent has gone to research relief.

In the massive and partisan $1.9 trillion budget reconciliation proposal being considered this week, billions and billions of dollars are going to special interests that already have $1 trillion in unspent funding sitting in the Treasury from previous COVID packages. And yet in all that spending, only $600 million was allocated to helping the research industry recover from the pandemic. That's less than half a percent.

We've relied on American science and scientists to combat COVID, but we're not giving them the funding they need to resume the work that's been stopped by the pandemic.

We need to act now.

I'm a proud cosponsor of the *RISE Act*, which would invest $25 billion in restarting American research. It provides the funding needed for researchers to complete work that was halted due to the pandemic. And it will allow federal science agencies to make awards to research universities, independent institutions, and national laboratories.

I'm also proud of the *Supporting Early-Career Researchers Act* Chairwoman Johnson and I re-introduced at the start of this Congress. This bill creates a new postdoctoral fellowship program at the National Science foundation to help support early career researchers.

Both of these bills enjoy strong bipartisan support, which is why I'm hopeful that we can move forward on them sooner rather than later. In the meantime, I'd like to thank our witnesses for being here today. I'm looking forward to learning more about the challenges facing our research industry, and hear your ideas about how we can support American science and technology.

Thank you.

Chairwoman JOHNSON. Our first witness, Dr. Sudip Parikh, is the Chief Executive Officer of the American Association for the Advancement of Science—we call it AAAS—and the Executive Publisher of the *Science* family of journals, a position he has held since January 2020. Prior to his current position with AAAS, Dr. Parikh served as Senior Vice President and Managing Director at DIA Global, the General Manager of the Health and Consumer Solutions Business Unit and Vice President at Battelle.

Our next witness, Dr. Christopher Keane, Dr. Keane is Vice President of Research (VPR) and professor of physics at Washington State University (WSU) where he has served since 2014. Prior to his positions there, he served in multiple leadership positions at Lawrence Livermore National Laboratory and the U.S. Department of Energy's (DOE's) National Nuclear Security Administration. Dr. Keane is also Chair of the Association of Public and Land-Grant Universities (APLU) Council on Research Executive Committee.

Our third witness, Dr. Felice Levine. Dr. Levine is Executive Director of the American Educational Research Association (AERA). Her work focuses on research and science policy issues, the scientific and academic workforce, and diversity and inclusion in higher education. Dr. Levine is engaged in a multi-method study of the impact of COVID–19 on early career education researchers and doctoral students.

Our next witness, Mr. Thomas Quaadman, Mr. Quaadman is Executive Vice President of the U.S. Chamber of Commerce Center for Capital Markets Competitiveness, the Chamber Technology Engagement Center, and the Global Innovation Policy Center. In his role with the Center for Capital Markets Competitiveness, he works to create and execute legislative, regulatory, and judicial strategies to reform the financial regulatory system and support policies for efficient capital markets.

Our witnesses should know that you will each have 5 minutes for your spoken testimony. Your written testimony will be included in the record for the hearing. And when you have completed your spoken testimony, we will begin with questions, and each Member will have 5 minutes to question the panel. We will now start with Dr. Parikh.

**TESTIMONY OF DR. SUDIP PARIKH,
CHIEF EXECUTIVE OFFICER, AMERICAN ASSOCIATION
FOR THE ADVANCEMENT OF SCIENCE**

Dr. PARIKH. Thank you. Chairwoman Johnson, Ranking Member Lucas, and Members of the Committee, thank you for the opportunity to testify today. As the CEO (chief executive officer) of the American Association for the Advancement of Science, or AAAS, and the Executive Publisher of *Science* magazine, I have the privilege of representing 120,000 scientists and engineers from every discipline, from agriculture and artificial intelligence (AI) to x-ray crystallography and zoology, who work tirelessly to advance science and serve society for the benefit of all.

And here's what they tell me. It seems strange to say it during a pandemic, but we live in wondrous times. The pace of discovery and innovation has never been faster. We've seen, we've seen the methane-covered mountains of Pluto. We have felt the gravitational ripples caused by colliding black holes. We have detailed extensive changes to our climate and environment. We've advanced quantum computing to the brink of broader utility and the creation of jobs and harnessed gene editing to potentially cure sickle-cell anemia and other diseases, not to mention the thrill of landing a rover on Mars in high-resolution no less.

Despite failures in our public health response to the pandemic, the biomedical research enterprise has never worked more quickly to understand and address COVID–19. The record-shattering number of submissions to the journal *Science* and other peer-reviewed publications for COVID, it speaks volumes about the speed and intensity with which researchers are responding to this crisis. And they haven't stopped in other areas either.

But we also live in uncertain times. Multiple intersecting challenges have the potential to become global crises. The COVID–19 pandemic is not going to be the last time that science is essential to society's triumph over existential threats. Addressing future public health concerns like Alzheimer's, climate change, food and water insecurity, and other challenges, some of which aren't even emerged yet, will require addressing short-term funding challenges and long-term support for science.

But we can't do things the way we've always done them either. The cadence of emerging crises and the pace of discoveries requires permanent elevation of scientific advisors to the front ranks of policymaking. And at the same time, we need to more fully engage diverse communities with an intentional emphasis on those that have been ignored, marginalized, or harmed by scientific advancement.

Today's hearing is incredibly timely. We are at an inflection point. As I said, we live in wondrous times for discovery, but that's a lagging indicator of previous investment. Unfortunately, due to the pandemic and slow erosion of investment, our Nation's universities and laboratories, the foundation of our innovation ecosystem, have faced an eroding capacity to nurture ideas, discoveries, and, most importantly, a highly skilled, diverse pool of STEM talent. And this is happening just as our global competitors are pouring investment into the sciences. What we do now could determine who benefits from scientific discovery in the form of better jobs and improved health.

Scientists and engineers have risen to the challenge of COVID–19, but this success has come at a price. Lab workers have been forced to work in shifts, and this limited lab time has slowed research. Lab budgets have been strained by the need to extend salaries. With needed safety measures in place, human subjects research has been particularly challenging. And field expeditions have been canceled or curtailed.

Early career researchers have been hit especially hard. For undergraduates in STEM, summer research programs were widely canceled, creating challenges in applying and progressing to grad school. For graduate students and postdoctoral researchers, job searches were suspended, leaving them in incredibly precarious positions of waiting for the job market to return.

Mental health has also been a continued concern. For women and underrepresented minorities in STEM, the pandemic has just further exacerbated already existing disparities. One recent survey found that female scientists and scientists with young dependents reported that their ability to devote time to the research has been substantially affected. Another found that students of color at research universities, as well as low-income and working-class students, were more likely to experience anxiety and depression, food and housing insecurity, and much higher rates of financial hardship.

Science involves problem-solving and collaboration. Every time a research project is shuttered or delayed or a promising scientist drops out of the workforce, it raises the question what discovery or development that could have made us safer, led to better jobs, or healed the sick has been lost?

This is the time to act. The wisdom and foresight of Congress in investing in science and engineering (S&E) has enabled America's global leadership. I look forward to discussing with you how we can ensure a future where the descendants of Native Americans, pilgrims, enslaved peoples, Ellis Island arrivals, and everybody else working together can come together to address the coming crises and build a better future for all Americans. Thank you.

[The prepared statement of Dr. Parikh follows:]

Written Testimony of Dr. Sudip Parikh
American Association for the Advancement of Science
Before the House Committee on Science, Space, and Technology
U.S. House of Representatives
February 25, 2021

Chairwoman Johnson, Ranking Member Lucas, and Members of the Committee, thank you very much for the opportunity to testify today. I am Sudip Parikh, chief executive officer of the American Association for the Advancement of Science. AAAS is the world's largest multidisciplinary scientific society and the publisher of the *Science* family of journals. Our mission is to advance science, engineering, and innovation throughout the world for the benefit of all people or – put more simply – to advance science and serve society.

Scientific discoveries are the result not of a single eureka moment but years of patient, dedicated, and funded work. Though this hearing is focused on impacts of the pandemic, it is important to consider why our government made the wise decision decades ago to invest in research and development.

Federally funded research has been a critical driver of world-changing discoveries for much of the past century and enhances the everyday lives of Americans in both large and small ways. These discoveries shape how we connect with each other, how we navigate through the world, and how we understand and make choices about our own health and the health of our loved ones.

The smartphones that sit in most of our pockets, for example, are an amalgamation of federally supported discoveries. The liquid crystal display, multi-touch screen zoom, and lithium battery all stem from research supported by the National Science Foundation (NSF). The Department of Defense (DoD) led the effort to establish the Global Positioning System, better known as GPS. Thanks to those efforts, freely available location data – accurate to less than a foot – is only an app away.[1] And speaking of apps, the internet itself, perhaps the most life-altering advancement in communication in our lifetimes, received crucial development support from NSF and the Defense Advanced Research Projects Agency (DARPA).[2] Federal investments in the National Aeronautics and Space Administration (NASA) have led to the invention and ubiquitous use of common household products, including scratch-resistant lenses, memory foam, and ear thermometers. Exhilarating achievements like the rover Perseverance's recent landing on Mars continue to inspire new generations of scientists and engineers to keep expanding the limits of our human reach.[3]

The topic of today's hearing – Building Back the U.S. Research Enterprise: COVID Impacts and Recovery – is incredibly timely for the following reasons:

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[1] https://spectrum.ieee.org/tech-talk/semiconductors/design/superaccurate-gps-chips-coming-to-smartphones-in-2018;
https://www.nasa.gov/directorates/heo/scan/communications/policy/GPS_History.html
[2] https://www.nap.edu/read/6323/chapter/9;
https://www.nsf.gov/news/special_reports/btyb/innovation.jsp
[3] https://www.jpl.nasa.gov/infographics/20-inventions-we-wouldnt-have-without-space-travel

First, over the past year the world has witnessed the critical role that U.S. science and engineering serves in developing diagnostics, therapeutics, and vaccines for the SARS-CoV-2 virus, giving us light at the end of the tunnel despite the relatively poor federal and state response to the COVID-19 pandemic.

Second, science and engineering research have an essential role to play in addressing a host of ongoing challenges that we face, including economic competitiveness, agriculture productivity, food and water security, energy security, and climate change. Unfortunately, our nation's universities and laboratories – the very foundation of our innovation ecosystem – have faced an eroding capacity to nurture ideas, discoveries, and a highly skilled diverse pool of STEM talent as a result of the pandemic.

The time is now to invest in R&D and seize the opportunities to restore and expand the STEM workforce pipeline to include majority and marginalized Americans, strengthen the U.S. innovation ecosystem, protect our economic competitiveness, and increase the safety and well-being of all Americans.

Science Rises to the Global Challenge

Starting in January 2020 and every day since, colleagues at *Science* and I have witnessed breathtaking scientific advancements in our understanding of the SARS-CoV-2 virus and rapid development of therapies and vaccines.

We published the research paper that revealed the structure of the spike protein that enables the virus to attach to a human host and replicate to cause the disease that we know as COVID-19. This rapid discovery and the subsequent advancements were made possible in large part by past federal investments in cutting-edge research. Researchers at the University of Texas at Austin and the National Institutes of Health (NIH) mapped the spike protein's structure within weeks of the release of the viral genetic sequence on January 10, 2020; their quick work relied on knowledge accumulated through years of basic research and led to record-breaking vaccine development for COVID-19. The journal *Science* highlighted this achievement as part of its Breakthrough of the Year, and AAAS and our partners recognized these scientists with the 2020 Golden Goose Award, which celebrates unexpected but world-changing discoveries.[4] This is just one of many striking examples of researchers across the globe working to combat the pandemic.

Many other examples of research across a multitude of scientific and technological fields continue to produce valuable information to help us respond to this global pandemic. AAAS, along with eight other organizations, founded the Golden Goose Award in 2012 to highlight stories of the world-changing benefits of federally funded, curiosity-driven scientific research. Past awardees include the scientist who discovered the proteins known as cytokines – which we now hear in reference to "cytokine storms" that characterize some severe cases of COVID-19 –

[4] https://science.sciencemag.org/content/367/6483/1260; https://www.goldengooseaward.org/01awardees/spike

and the field biologists whose discoveries led to the PCR technique of amplifying and analyzing DNA, which is used in COVID-19 diagnostic tests.[5]

This brief list of scientific advances, many of which were the result of unanticipated and serendipitous discoveries, offers just a glimpse into the varied ways that federally funded research has the potential to touch every aspect of our lives and underscores the importance of continuing to fund these vital endeavors.

Even now, time and again, researchers have rallied and found creative opportunities to continue their work, despite massive obstacles. Their ingenuity has included shifting and redirecting research to focus on the pandemic, retrofitting laboratories and equipment, and finding new ways to work in this era of social distancing.

For example, we heard from an Iowa researcher who studies virtual reality training for soldiers, first responders, and other populations including factory workers. For safety reasons, the researcher's team had to transition experiments to a home setting, which posed significant challenges: developing new software and data transfer capabilities, working with an Institutional Review Board for approval of the new experiment design, and finding new methods to recruit subjects and interpret their data. Though scientists and engineers are rising to the moment and using their talents to solve problems, these solutions do have costs, as in the case with this researcher: milestones postponed with funding agencies, delayed graduation for students, and the need for bridge funding to help support those who work in the lab after the grants run out.

This raises a troubling question: what groundbreaking science, currently underway, might be lost as a result of funding constraints associated with the pandemic? With this interruption, what life-changing advances might we never get to see?

Success Comes with a Price

This committee held a hearing in September 2020 to address the significant disruptions to research conducted at our nation's universities. As the pandemic emerged, universities were faced with determining what was essential research to continue, in some cases retrofitting labs to focus on COVID-19 research and creating a safe environment for researchers and students. For some scientific disciplines – particularly research that involves field studies, longitudinal studies, and non-COVID-19 research involving animals and humans – significant amounts of research have been lost. We've heard from members who have had to restructure experiments, leave field work unfinished, and face delays in project completion, publications, and the supply chains for needed equipment. To be sure, some important research has continued – for example, *Science* has covered key scientific developments over the past year in areas such as genome editing,

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[5] https://www.goldengooseaward.org/01awardees/cytokines; https://www.goldengooseaward.org/01awardees/thermus-aquaticus

neutron stars, climate change and policing.[6] Impacts are affecting some individuals more than others.

There are human and social factors, as growing evidence shows that the pandemic has exacerbated preexisting inequities among women and other underrepresented minorities in the scientific community. As you'll hear from Dr. Levine, early-career researchers – graduate students, postdoctoral researchers, and new faculty – have lost or risk losing research opportunities and job prospects.

Women in STEM, and those with young children, have faced unique challenges. One recent survey of principal investigators found that "female scientists and scientists with young dependents reported that their ability to devote time to their research has been substantially affected, and these effects appear additive: the impact is most pronounced for female scientists with young dependents."[7] Multiple analyses have also pointed to a drop in submissions by women on preprint servers, which allow versions of scientific manuscripts to be posted online prior to formal peer review.

According to a global survey of 20,000 Ph.D. holders referenced in a National Bureau of Economic Research working paper last month, mothers suffered a 33 percent larger drop in research hours than fathers. The survey, conducted from May to July 2020, also found that mothers took on more household and childcare duties than fathers.[8]

A Policy Forum published in our own journal, *Science*, about moving academic research forward during the pandemic, laments that "longstanding affordability and child- and family-care disparities across the research workforce – which disproportionally affect women, lower-income support staff, and trainees – are more clear than ever given the sudden and asynchronous sector closures and cost-saving measures implemented at many institutions."[9]

Underrepresented minorities in STEM have also been disproportionately impacted. The Student Experience in the Research University Consortium conducted a survey last year on the impact of COVID-19 on students at 10 research universities.[10] The survey, which received responses from about 30,000 undergraduate and 15,000 graduate and professional students, consistently found that students of color, as well as low-income and working-class students, were more likely to experience anxiety and depression, food and housing insecurity, and higher rates of financial hardship for both themselves and their families than their white and higher-income counterparts.[11] The American Medical Association provided further examples of how existing

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[6] https://science.sciencemag.org/content/371/6530/696; https://science.sciencemag.org/content/370/6523/1402
[7] https://www.nature.com/articles/s41562-020-0921-y
[8] https://www.nber.org/papers/w28360
[9] https://science.sciencemag.org/content/368/6496/1190.full
[10] https://cshe.berkeley.edu/seru-covid-survey-reports
[11] https://www.insidehighered.com/news/2020/09/16/low-income-and-students-color-greatest-need-pandemic-relief

inequities in our society have been exacerbated by the pandemic, with deleterious effects for racially marginalized groups. To name just a few examples, students of color and from lower-income backgrounds may face reduced access to the technology and bandwidth that makes virtual education possible. And people of color are experiencing the health effects of COVID-19 disproportionately, which means that students of color are likely to be shouldering an increased burden of grief.[12]

The pandemic has also added burdens to researchers with disabilities. Krystal Vasquez, a graduate student in atmospheric chemistry at the California Institute of Technology who has hypermobile Ehlers–Danlos syndrome, a connective tissue disorder, found that unpaid time spent advocating for COVID-related policies that protect disabled and chronically ill students took time away from her work hours. Additionally, though the option to work from home has been helpful to many disabled people, the disability community has voiced concern that when the pandemic ends, research institutions will remove the options that currently increase accessibility.[13]

We must not set in motion a future where fewer women and minorities submit research grant proposals and research publications, where career opportunities for promising scientists are derailed, and where mentors for future scientists are in shorter supply.

That Price Risks our Innovation Future

Our failure to sustain our investment in research and development (R&D) is threatening not only Americans' opportunities, but our innovation leadership. The ability of the United States to compete with other countries, including China, should be thoughtfully considered by this committee and Congress. Make no mistake, we remain in a global race for innovation advantage, and we've been allowing ourselves to slip. Since the mid-1990s, we have fallen to 10th in the world in R&D intensity – R&D as a share of a nation's GDP – and 14th in the world in *public* R&D intensity.[14] China continues to gain on our lead in total R&D expenditures, has risen to second in the world in highly-cited researchers and highly-cited publications, and since 2008 has experienced a 500 percent rise in triadic patents, which are patents for the same invention filed in multiple international patent offices and a good measure of innovative capacity.[15]

It's not just China: other economies like Germany, Korea, and Taiwan also rank ahead of the United States in metrics like R&D intensity and researchers per capita.[16] Some of these same countries are pumping billions into their research and innovation ecosystems to jumpstart a path forward for COVID relief.

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[12] https://www.ama-assn.org/delivering-care/public-health/protecting-underrepresented-students-and-residents-during-covid-19

[13] https://www.chemistryworld.com/careers/underrepresented-scientists-hardest-hit-by-pandemic/4012868.article

[14] https://www.aaas.org/news/snapshot-us-rd-competitiveness-2020-update

[15] https://clarivate.com/blog/highly-cited-researchers-2019-strong-evidence-of-mainland-chinas-rise-to-the-highest-levels-of-research/;
https://ncses.nsf.gov/pubs/nsb20206/impact-of-published-research

[16] https://www.aaas.org/news/snapshot-us-rd-competitiveness-2020-update

These are not just statistics. The trends have real and tangible effects at home and in our communities. Failing to take the right steps means not just the loss of innovations or companies but human capital and losing high-skilled jobs and opportunities. An analysis of job boards during the fall application season revealed that STEM postings were down by about 70 percent.[17]

Approximately one in four doctoral students and half of all postdocs – representing the next generation of STEM innovators – rely on federal financial support, and the federal government is the largest source of support for university research, an important foundation of not just discovery but training.[18] Universities are increasingly important influences on the inventive activities of nearby firms and on the creation of new startups.[19] Having a ready workforce of skilled science graduates is also important for firm innovation.[20] Disruptions to this ecosystem can have serious ripple effects on the broader innovation economy.

Postdocs and early-career researchers will go where the opportunities are. The U.S. has always been that place. But if we do not respond appropriately to this pandemic, we risk losing this talent at great detriment to our nation.

Recommended Steps for Research Relief

We recognize that there are many sectors of the U.S. society and our economy that have been negatively impacted by the COVID-19 pandemic. Unfortunately, our scientific and technology enterprise, which will be integral to helping our nation move forward, is also at risk from the COVID-19 pandemic.

The Council on Governmental Relations (COGR) has calculated the estimated costs of the pandemic on academic research institutions. The January 2021 update laid out three sobering impacts at U.S. research universities: "1) research output losses between 20 and 40 percent, 2) financial disinvestment impact in the *hundreds of millions of dollars* at individual institutions, and 3) potential impact approaching *tens of billions of dollars* across the entire U.S. research enterprise."[21]

Timely funding is needed to address the urgent challenges described above, particularly the most important asset in the scientific enterprise – highly skilled, diverse scientists and engineers. Buildings and experimental tools can be replaced on the legislative schedule, but people cannot wait.

Research relief is necessary to avoid the long-term impacts of the COVID-19 pandemic on the U.S. research and innovation enterprise, and legislation such as the bipartisan, bicameral RISE

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[17] https://www.sciencemag.org/careers/2020/10/amid-pandemic-us-faculty-job-openings-plummet
[18] https://ncsesdata.nsf.gov/gradpostdoc/2018/html/gss18-dt-tab003-1.html;
https://ncsesdata.nsf.gov/gradpostdoc/2018/html/gss18-dt-tab003-2.html;
https://www.aaas.org/sites/default/files/2018-11/UniSource1.jpg
[19] https://doi.org/10.1068/a3930
[20] https://doi.org/10.1016/j.respol.2014.03.005
[21] https://www.cogr.edu/sites/default/files/Research_Impact_COVID_Jan_2021_COGR.pdf

Act lays out a funding plan supported by the community. As I've outlined in my opening remarks, the success of this enterprise has benefited from federal funding of cutting-edge research across multiple mission agencies. The RISE Act supports that foundational principle.

The $25 billion authorized in the RISE Act is an estimate based on the disruptions in the early months of the pandemic. It authorizes funding to fill urgent gaps across key federal agencies that further research to promote national security, energy security, and food security, as well as public health and environmental protections. The longer we postpone this vital support, the higher the costs will be, and federal agencies will be faced with determining whether to fund cost extensions to existing research disrupted by the pandemic or fund new grants that will allow our innovation enterprise to regain momentum.

Funding is only part of the solution. We encourage federal agencies and research institutions to work in partnership in developing policies that do not reflect a "one-size-fits-all" approach as they consider bridge funding of existing grants and funding new research grants. The higher education community has outlined a number of policy actions that can be implemented to support scientists and students at U.S. universities.[22]

In addition, policies that provide support for early-career scientists, women and underrepresented minorities can help to ensure that we do not lose even the small gains we have made in diversifying our science and technology workforce – for example, Chairwoman Johnson and Ranking Member Lucas's Supporting Early-Career Researchers Act. We encourage Congress to work with the new administration to explore opportunities to expand the number of research fellowship programs and to provide additional flexibilities to assist researchers whose studies have been interrupted and delayed. The creativity and innovation boost that comes from diverse teams is critical in competing with the sheer numbers of scientists and engineers being produced by our global competitors such as China. Our greatest asset is scientific excellence coupled with the diversity of thought derived from the diversity of the experiences on our teams.

Understandably, the government has a keen interest in allowing ongoing research to resume and regain its pace, but we must also invest in new early-career scientists waiting to begin their research and expand our scientific and technological horizons, lest we create a clog in the STEM talent pipeline or altogether lose this talent to other sectors.

I cannot emphasize enough the importance of responding with urgency as soon as possible. Funds received a year from now may provide some eventual relief to institutions, but they will be too late for young scientists and engineers struggling to stay afloat in these turbulent and uncertain times.

Looking beyond the urgent needs of the pandemic, science has always had strong bipartisan support from the U.S. Congress – and the American people have benefited greatly from those past investments. We thank you for your foresight and the funding that has been appropriated over the past years, and we encourage the members of this committee to continue to work in partnership with your colleagues in providing robust and sustainable funding for R&D this year

[22] https://www.aau.edu/sites/default/files/AAU-Files/Key-Issues/Federal-Budget/COVID-Priorities-for-117th-Congress.pdf

to allow our nation to continue to push the envelope of scientific discovery, harness technological advancements, advance economic opportunities, and protect our citizens from the next crisis.

In July 2020, I testified before the House Budget Committee on American innovation. In my remarks I urged policymakers to renew investments in our research enterprise, and in conclusion, I would like to emphasize this point again today. We are living in an era in which science and engineering have delivered extraordinary advances that are improving health, well-being, and economic prosperity for Americans and people around the world – and we are on the cusp of even more life-improving developments and discoveries. But we must not lose sight of the critical role that science serves in identifying new threats and revealing new horizons. Done well and learning from the past, supporting our nation's scientific enterprise will be vital to serving the well-being of all our citizens and bolstering economic security for all. I am confident in the ability of the people in our science and technology enterprise to rise to the challenges of the coming era, but they cannot do it without your leadership and support.

Sudip S. Parikh, Ph.D.
Chief Executive Officer and Executive Publisher, *Science* Journals
American Association for the Advancement of Science (AAAS)

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Sudip Parikh, Ph.D., became the 19th chief executive officer of the American Association for the Advancement of Science (AAAS) and executive publisher of the *Science* family of journals in January 2020. Parikh has spent two decades at the nexus of science, policy, and business.

Immediately prior to joining AAAS, Parikh was senior vice president and managing director at DIA Global, a neutral, multidisciplinary organization bringing together regulators, industry, academia, patients, and other stakeholders interested in healthcare product development. He led strategy in the Americas and oversaw DIA programs that catalyzed progress globally toward novel regulatory frameworks for advanced therapies not amenable to existing regulations.

Prior to DIA, Sudip was general manager of the Health and Consumer Solutions business unit and vice president at Battelle, a multibillion-dollar research and development organization. He led a $150 million business unit with over 500 scientific, technical, and computing experts performing basic and applied research, developing medicines and healthcare devices, and creating advanced analytics and artificial intelligence applications to improve human health. Previously, Parikh led Battelle's global AgriFood business unit. Headquartered in London and Geneva, this unit provided environmental fate research and agriculture product development services from laboratories throughout Europe and the United States.

From 2001 to 2009, Parikh served as science advisor and professional staff to the United States Senate Appropriations Committee, where he was responsible for negotiating budgets for the National Institutes of Health (NIH), Centers for Disease Control and Prevention, Agency for Healthcare Research and Quality, Biomedical Advanced Research and Development Authority, and other scientific and health agencies. A key legislative liaison to the research and development ecosystem, Parikh was on the frontlines of many science policy issues debated during that time, including embryonic stem cell research, cloning, disease surveillance, bioterrorism, cyber security, and doubling the NIH budget.

An active member of the scientific advocacy community, Parikh serves as a board member and officer for several impactful organizations, including Research!America, Friends of Cancer Research, and ACT for NIH. He has received multiple public service awards, including recognition from the American Association of Immunologists, the National AIDS Alliance, the Coalition for Health Services Research, and the Juvenile Diabetes Research Foundation.

Sudip is committed to early STEM education and, as a parent of three energetic young children, he prioritizes volunteering as a mentor for Science Olympiad teams at two elementary schools.

Early in his career, Parikh was a Presidential Management Intern at the NIH. He was awarded a National Science Foundation Graduate Research Fellowship while earning his Ph.D. in macromolecular structure and chemistry from the Scripps Research Institute in La Jolla, Calif. There, he used structural biology and biochemistry techniques to probe the mechanisms of DNA repair enzymes bound to DNA. The son of Indian immigrants who worked in the textile and furniture manufacturing plants of North Carolina, Parikh completed undergraduate studies at the University of North Carolina at Chapel Hill, first as a journalism major before switching into materials science.

January 2020

Chairwoman JOHNSON. Thank you very much. Dr. Christopher Keane.

TESTIMONY OF DR. CHRISTOPHER KEANE,
VICE PRESIDENT FOR RESEARCH,
WASHINGTON STATE UNIVERSITY

Dr. KEANE. OK. Good morning. Chairman Johnson, Ranking Member—Chairwoman Johnson, Ranking Member Lucas, and Members of the Committee, thank you for the opportunity to testify today before the Committee regarding the contribution of the Nation's universities to building back the U.S. research enterprise and the impacts of the COVID–19 pandemic. My name is Christopher Keane, and I'm Vice President for Research at Washington State University. In my capacity as VPR at WSU, I serve as Chair of the Association of Public and Land-Grant Universities Council on Research.

I want to highlight the work that WSU and our fellow public and land-grant institutions are doing to support our public health and economy during the pandemic, the impact the pandemic has had on our research enterprise, and the role Congress can play in mitigating the challenges research institutions across the country face.

The Nation's public and land-grant universities, echoing the last speaker, indeed, have risen to the challenge in the campaign against the coronavirus. This includes conducting research relevant to COVID–19, testing, support of campus and community vaccination efforts, and other activities needed to return students to school and support the safe resumption of university programs while ensuring the health of our communities.

Working with local, State, and national public health officials, industry, and other organizations, universities are making adjustments to meet the needs of our students, researchers, and communities. For example, WSU's Washington State Animal Disease Diagnostic Laboratory (WADDL) has been modified to conduct CLIA (Clinical Laboratory Improvement Amendments)-certified—that's the FDA (Food and Drug Administration) approval process—testing for the SARS-CoV–2 virus. To date, WADDL has processed over 67,000 samples from surrounding residents, including about 25,000 samples from WSU faculty, students, and staff. WSU has provided cold storage for vaccines and is also partnering in the delivery of over 12,000 doses to residents in eastern Washington.

The university has continued to face severe impacts right now, including delays and disruptions to undergraduate and postgraduate education, revenue losses, and increased operational costs; amplification of gender, racial, and other previously existing inequities; disruption of the flow of talent, infrastructure impacts; food and housing insecurity, unfortunately; lack of childcare, and other factors. These impacts directly undermine our ability to support the fundamental research that drives innovation. Indeed, economists estimate innovation provides 50 percent of annual U.S. GDP (gross domestic product) growth.

One story, at WSU Vancouver, one of our assistant professors recently shared this tale, quote, "At the start of the pandemic, my children and I were targeted with racial slurs just because we were Asian American, and we didn't cause the pandemic. Add to that the

emotional stress I have from homeschooling my special-needs child, and I just don't have the energy or ability to produce research papers. After many months of non-productivity, I finally chose to give up sleeping. I now regularly have resumed some sleeping, only getting 2 or 3 hours a night just so I can keep writing papers and stay on track for my career." That's a real story, and there's numerous others.

WSU and the Nation's academic community are grateful for the Federal assistance provided by Congress over the past year. As Congress considers additional stimulus and recovery funding, I urge the Committee to pass the *RISE Act* that will provide $25 billion to Federal research agencies to support projects at independent research institutions, public laboratories, and universities throughout the country. The funding would also support early career researchers and graduate students, researchers and disciplines not fully covered such as human subject research and field work and vital facilities.

Making full use of all our national talent is critical to recovery, advancing the U.S. research enterprise, and remaining competitive globally. China's current annual R&D (research and development) expenditure growth exceeds that of the United States by roughly $60 billion, which in fact is double the total request for the *RISE Act*. So even if all the *RISE Act* funding were applied to federally funded research—and there are many other costs as well, of course—China would remain on a path to exceed U.S. R&D expenditures in the near future, ultimately threatening our position as the world leader in an innovation economy.

We also need to encourage students to follow a career path in research, and I urge the Committee to support the *Early Career Researchers Act*. This will provide the financial support necessary for young researchers to be hired who may be otherwise lost to our national enterprise due to the current crisis.

On behalf of the Nation's public and land-grant universities, I appreciate the opportunity to speak here today and express our thanks for the support provided by the Committee and Congress. The resources you have provided are allowing our research universities to meet the challenges of COVID–19. The pandemic, however, has emphasized and in many cases amplified many of the existing shortfalls I have outlined. I urge the Committee to support the *RISE Act* to advance the research enterprise at our universities and the fundamental research and new ideas it drives, allowing the U.S. innovation economy to flourish and better the lives of all Americans.

Again, thank you for the opportunity to testify today. I look forward to answering any questions you may have.

[The prepared statement of Dr. Keane follows:]

Statement of Christopher J. Keane
Vice President for Research and Professor of Physics
Washington State University
Pullman, WA
and
Chair of the Association of Public and Land-Grant Universities Council on Research

before the

Committee on Science, Space, and Technology
U.S. House of Representatives
February 25, 2021

Introduction

Chairwoman Johnson, Ranking Member Lucas, and members of the Committee, I am Vice President for Research at Washington State University (WSU). I also currently serve as Chair of the Association of Public and Land-Grant Universities (APLU) Council on Research (COR). Thank you for the opportunity to testify before the Committee today regarding our nation's efforts to build back the U.S. research enterprise from the impacts of the COVID-19 pandemic.

WSU is Washington state's land-grant university and a public research university committed to its mission and tradition of service to society. With six campuses[1] across the state of Washington and a presence in every county through its Extension system, WSU has an enrollment of 31,159 students statewide. More than 9,000 students are first generation. Additionally, WSU employs more than 6,250 faculty and staff. In FY2019, WSU's total operational budget was approximately $1.2 billion dollars, including research and development expenditures totaling $345 million.

As I indicated, I also serve as the Chair of the APLU COR. The APLU COR consists of the chief research officers at member campuses and systems with responsibility for policy and administration associated with research, scholarship, and creative activity. Along with other APLU units, COR looks at strategic issues impacting the public and land-grant university research enterprise and monitors compliance and regulatory issues affecting research. APLU's 199 U.S. member campuses enroll 4.2 million undergraduates and 1.2 million graduate students, award 1.2 million degrees, employ 1.1 million faculty and staff, and conduct $46.8 billion in university-based research. The latter figure represents approximately 60% of the nation's university-based research and development. My position as APLU COR Chair has given me the opportunity to discuss the impacts of the COVID-19 pandemic across a wide segment of U.S. institutions.

WSU has been a leader in The Science Coalition working with other Coalition members to highlight the benefit of the federal investment in research provided by Congress. I want to thank you, Madam Chairwoman and Ranking Member Lucas, for your support of science funding that is so critical to discovery, innovation, and improving the lives of our people through advancing research, scholarship and creative activity.

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[1] WSU campuses are located in eastern Washington (the main campus in Pullman, and the WSU Health Sciences campus in Spokane), south central Washington (WSU Tri-Cities in Richland), and western Washington (WSU Vancouver and WSU Everett). WSU also has a large and active online Global Campus.

Overview

In my testimony, I will focus on three points:

1) The nation's public and land-grant universities have "risen to the challenge" and played critical roles in supporting their communities, states, and the nation in the campaign against SARS-CoV-2. This includes conducting research directly applicable to mitigation of COVID-19. It also includes testing, support of campus and community vaccination efforts, epidemiological studies, and other activities needed to support resumption of university programs in a safe manner while simultaneously working to ensure the health of surrounding communities. Universities have partnered effectively with local, state, and national public health officials and other organizations in this effort. These successes underline the importance of fundamental science in responding to the pandemic, and would not have been possible without the long term investments in educational and research programs made by state and federal governments. In short, the pandemic has highlighted the importance and public impact of the nation's research universities.[2]

2) While the nation's public and land-grant universities have risen to the challenge of COVID-19, the pandemic has had numerous and severe impacts – both short and long term. These include impacts to undergraduate, graduate, and postdoctoral education; partial or complete loss of some research; amplification of gender, racial, and other previously existing inequities; disruption of the flow of talent required to support the nation's "innovation pipeline;" infrastructure impacts; and other factors. The overall impact on innovation is particularly concerning as it is estimated to provide 50% of annual U.S. GDP growth.

3) APLU, its member institutions, and the nation's academic community are grateful for the support Congress has provided via the CARES Act and other means. Looking ahead, continued Congressional support for federal research agencies will be essential for national recovery from the pandemic and transitioning the nation's research enterprise to the "new normal," which assuredly will not look like the situation pre-pandemic.

APLU Universities Have "Risen to the Challenge" of Combating the Pandemic

This past year has been the most challenging in memory. It has been no different for the public university community. The pandemic has upended every facet of public research universities' mission – from education to research and community and industry engagement.

Overall response and university research output

The responses of the nation's public and land-grant research universities to the pandemic share many similarities.[3] As part of the initial set of nationwide restrictions and lockdowns in the March 2020

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[2] See https://www.aplu.org/projects-and-initiatives/research-science-and-technology/public-impact-research.html/ for further information on the public impact of research universities generally.

[3] Additional detail and examples regarding the March 2020 ramp-down and subsequent ramp-up of university research activity, as well as examples of coronavirus-related university research, are available in the testimony of the September 9, 2020 hearing of the Subcommittee on Research and Technology of the House Committee on Science, Space, and Technology.

timeframe, universities across the country took steps to limit on-campus research activities based on public health considerations and stay at home orders. Most research was transitioned to telework, with on-campus activities generally limited to essential work such as maintenance of critical infrastructure required to ramp up research once adequate personnel protection and safety measures were in place.

As state and local directives allowed activities to gradually resume in the May-June timeframe, universities began to ramp up on-campus research activities. University research could not be promptly brought back to the pre-pandemic level, however. Laboratory research has not returned to a normal pace due to reduced personnel density to accommodate pandemic-related personnel spacing guidelines, personnel and budget constraints, and other reasons. Research involving human subjects[4] was particularly impacted. At WSU, for example, human subject research was reduced to approximately 10% of the pre-pandemic level. It has resumed only to the 15% level due to public health considerations, with individual projects approved on a case-by-case, exception basis. Global health research, including U.S. government funded programs, focused on early detection and response to emerging infectious diseases—similar to and including COVID-19—has been severely constrained by the pandemic impact in the U.S. and internationally, and the subsequent inaccessibility and/or prohibition of international travel. As an example, a NIH Fogarty International program to train an integrated cohort of physicians and veterinarians to detect, diagnose, and respond to human infections emerging from animals has been delayed a full 12 months due to the pandemic.

Detailed estimates[5] of the impact of this novel coronavirus suggest an overall loss of research output nationwide, from March 2020 through March 2021, of approximately 20%-40%. This is consistent with our experience at WSU. We estimate our research enterprise was operating at approximately 60% of the pre-pandemic level following our June 2020 limited ramp up of on-campus research. We now estimate output of the WSU research enterprise is approximately 70% of the pre-pandemic level. Note that individual research projects span the entire spectrum of productivity (0-100%); research projects fully dependent on face-to-face interactions or those requiring individuals to be in extended close contact have not been able to collect new data, whereas research that could pivot remotely is fully operational.

Ramp-up of the research enterprise, including testing and vaccination

The bulk of APLU universities implemented some form of coronavirus testing in the spring/summer 2020 timeframe. This testing was strongly motivated by understanding the nature of disease spread within the campus and local community for both public health purposes and to support university decision making regarding the resumption of on-campus instruction, research, and other

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[4] Human Subjects Research, according to HHS and FDA regulatory definitions, involves human participants or their identifiable information or specimens, and can be broadly described in two categories: 1) Biomedical Research, including interventions to test drug efficacy, device or therapeutic treatment method (e.g. clinical trials), studies on the human genome, or studies of physical, mental, psychological or physiological conditions (e.g. cognitive disorders, pregnancy). and 2) social, behavioral and educational research, including sociological research (e.g., criminal justice, social justice, race, social movements, mass media, gender and sexuality), behavioral research (e.g., autism, adolescent behavior, emotional analysis, sensory science, eating behaviors, and consumer behaviors), and educational research (e.g., classroom learning, pedagogy, technology use, standardized testing, and instructor education and training)

[5] See the August 2020 Council on Government Relations "Research Impact Under COVID-19" report (https://www.cogr.edu/sites/default/files/Research_COVID_August2020_COGR_FINAL.pdf) and its January 2021 update (https://www.cogr.edu/sites/default/files/Research_Impact_COVID_Jan_2021_COGR.pdf).

activities. Much of this testing activity was done in close collaboration with local, state, and national public health officials. In many cases, including at WSU, Oklahoma State University, Purdue University, and elsewhere, on-campus testing capabilities relied on existing infrastructure, often within schools of veterinary medicine. Within the APLU community, Oklahoma State University launched an early and intensive effort to develop testing capability for both their campus and their state. This provided valuable insight and experience for other APLU members to model.

At WSU, the Washington Animal Disease Diagnostic Laboratory (WADDL), a Level 1 laboratory in the USDA National Animal Health Laboratory Network on the Pullman campus, has been used to conduct limited testing of both human and animal samples for the SARS-CoV-2 virus, the causative agent for COVID-19 in humans. WADDL developed and validated specific laboratory tests at the request of federal, state, and county animal and public health agencies to assist in the response to the COVID-19 pandemic as required under the Clinical Laboratory Improvement Amendments of 1988 (**CLIA**). WADDL supports WSU testing of its faculty, staff, and students, and processes samples for organizations testing residents throughout eastern Washington. The results of human testing are reported to public health agencies and contribute to a state and international database sharing effort for all scientists and healthcare providers to better understand the SARS-CoV-2 virus and combat the spread of COVID-19. Voluntary asymptomatic COVID-19 testing is available for faculty and staff working in Whitman County, location of our Pullman campus. Testing is available at no cost only to individuals not currently experiencing COVID-19 symptoms. Symptomatic faculty, students, and staff are referred to their health-care providers.

Since the initial investment in and implementation of SARS-CoV-2 viral infection testing in spring and summer 2020, university testing activities have matured and are now essential tools in fighting the pandemic and guiding the resumption of normal university activities. Since its summer 2020 launch as a testing facility, WADDL has processed more than 25,500 samples from WSU faculty, staff, and students. In total, WADDL has processed over 67,000 samples from eastern Washington. Notably, WSU testing of asymptomatic faculty, staff, and students at other public (Eastern Washington University and University of Washington) and private (Gonzaga University and Whitworth University) universities in the Spokane area has supported execution of their educational programs.

This semester at WSU, 66 classes (approximately 5% of the total) with experiential learning currently have an in-person component on our Pullman campus compared to 35 classes in fall 2020, with approximately 1,300 students living on campus. As students returned to our Pullman and Spokane campuses for spring semester, WSU requested every arriving student undergo arrival testing to mitigate the spread of COVID-19. WSU completed more than 8,000 COVID-19 tests for students in January 2021. The arrival testing program has been successful in stopping the spread of the virus both on campus and throughout the Pullman community. As of February 10, the WSU Pullman campus has reported only 11 active cases (and Spokane only five active cases) of COVID-19 in both students and employees currently in their 10-day isolation period. In fact, there has been no known transmission of the virus in a research space such as a laboratory.

WSU staff also assist Washington State Department of Health (DOH) in contact tracing efforts of individuals testing positive, including providing quarantine and isolation hotel rooms. Ongoing diagnostic and screening testing remain available on the Pullman campus. WSU's epidemiological modeling, coupled with testing and other data, has been essential in determining ongoing screening testing requirements and has also provided insight to eastern Washington healthcare providers in terms of required hospital beds and other needs.

More recently, WSU partnered with local and state health authorities and the private sector, including Schweitzer Engineering Labs in Pullman, Incyte Diagnostics, and Providence health system in Spokane, to support Washington state's vaccination efforts. WSU provides vaccine cold storage capability for eastern Washington, as are other land-grant universities who serve rural parts of the country. As of February 15, the university has partnered in the delivery of over 12,400 vaccine doses to residents of eastern Washington, and those that work within this region from neighboring states.

Overall, the combination of testing, vaccination, careful design and implementation of COVID-19 personnel safety practices, epidemiological modeling, and close partnership both within universities and externally with public health and other partners has allowed university activities, including research, to steadily increase since the initial ramp-up of on-campus activities in spring 2020. This included a large uptick in research related to COVID-19 but also research in other areas, including social science research that will help us navigate the societal inequalities exacerbated by the pandemic.

At WSU, nearly 150 scientists pivoted their work from existing projects to research contributing to our understanding of COVID-19 and its impact on society. For example, WSU researchers are working closely with CDC-Kenya to expand the existing infectious disease surveillance platforms in Kenya to investigate the transmission patterns, disease severity, clinical presentation, and risk factors for infection of COVID-19 in the country. Another WSU research study is investigating the unintended consequences of COVID-19-related public health measures of deferred cancer treatments.

WSU researchers were also part of a multi-institutional research team led by the University of Idaho that included the University of Rochester School of Medicine and Dentistry and Medical Center, Brigham and Women's Hospital, and Harvard Medical School to study whether breastfeeding women who have COVID-19 transfer milk-borne antibodies to their babies without passing along the SARS-CoV-2 virus. Researchers analyzed 37 milk samples submitted by 18 women diagnosed with COVID-19. None of the milk samples were found to contain the virus, but nearly two-thirds of the samples did contain two antibodies specific to the virus. This research is now informing national and global guidance related to COVID-19 and breastfeeding.

At the University of Iowa, genetics expert Val Sheffield has converted part of his lab to help fight the coronavirus pandemic by creating a simple specimen-collection method that skips the swab and removes the need for medical personnel. All people must do is spit in a cup. Allowing people to collect their own saliva at home helps them avoid potentially risky contact with people at testing sites, supports keeping health care workers healthy, and preserves personal protective equipment (PPE).

In September, North Carolina State University's Nonwovens Institute (NWI) announced a new partnership with Blue Cross and Blue Shield of North Carolina, Freudenberg Performance Materials, UNC Health, the NC Healthcare Association, and NC Medical Society to manufacture N95 masks to equip frontline workers across North Carolina with safe and cost-effective protection from the virus. Two mask-making machines are housed at Durham-based Freudenberg Performance Materials, which provides the manufacturing expertise and workforce needed to install, operate, and maintain the new production lines using novel materials provided by NC State's NWI. As masks become available, the NC Healthcare Association and NC Medical Society will conduct outreach to providers who may lack staffing capacity and contacts to place accelerated orders. UNC Health will provide infection prevention experts who will perform rigorous testing to ensure the respirators offer the highest levels of protection and meet industry health and safety standards.

The U.S. Office of Management and Budget (OMB) provided flexibility on federal sponsored project execution that has been essential to mitigate the effects of the pandemic and ramp-up research activities such as those described above. APLU and its member institutions are very grateful for this support. In particular, in response to the pandemic, OMB issued three memoranda in spring 2020 directing federal agencies to marshal all legally available resources to combat the crisis. The three memoranda relaxed short-term administrative, financial and audit requirements and allowed federal agencies to grant related flexibilities to their recipients, including the extension of single audit submissions and salary payments through September 30, 2020. The most useful flexibilities contained in these memoranda were the ability to charge salaries to grants for people unable to work or worked at reduced productivity, the ability to donate equipment and resources, such as PPE and labor, paid for with grant funds to COVID-19 clinical response, the extension of reporting deadlines, and no-cost extensions. The three memoranda provided universities with the ability to preserve and maintain the underlying research infrastructure during the height of the crisis. Without the ability to maintain the research workforce by paying salaries of those who could not come on campuses, institutions would have been forced to furlough or lay off researchers and scientific staff. Similarly, the flexibilities permitted research infrastructure, such as cell cultures and animal colonies, to be maintained throughout the period when on-campus lab activities could not be performed, as well as through the current ramp-up period of on-campus activities. These provisions all expired on September 30, 2020.

Individual federal agencies such as National Science Foundation (NSF) and National Institutes of Health (NIH) also provided important relief and support to the research community to support its fight against COVID-19. As an example, NSF announced in April 2020 the availability of its RAPID (Rapid Research Response) funding mechanism for COVID-19 related research. Numerous universities, including WSU, have received such "rapid response" grants- and they have been timely. In fact, the work discussed above involving transfer of antibodies specific to the virus to breast-fed babies was partially funded by an NSF RAPID grant.

Land-grant institutions supporting local communities: WSU examples

The pandemic has emphasized the critical importance public and land-grant universities play in serving their local, state, and national communities. Extension programs within these universities typically play a critical role in such service. Examples of WSU Extension contributions are discussed below. Additional examples are available from APLU.

WSU's Extension programs in partnership with the Washington State Broadband office have provided WSU students and employees, and community members, with free Wi-Fi hotspots. In Washington state, nearly one in 10 rural residents lack access to high-speed broadband. Nationally, 15 percent of rural Americans are offline. For students, limited access hinders their ability to contact advisors or access academic resources. WSU launched the Drive-In Wi-Fi partnership in late April 2020 that began to place broadband access points at WSU's county and tribal Extension centers, as well as schools, libraries, and community centers across the state. Members of the public can also access the Internet using drive-in hotspots, through a separate public portal. The program quickly drew support from the Washington State Broadband Office, Microsoft Corporation, Avista, Washington State Library, a division of the Secretary of State, and other partners. WSU's initiative to set up Wi-Fi hotspots is emblematic of what other land-grant universities have done.

WSU's Food Systems program is addressing several issues to assess and improve food access and food security challenges related to the COVID pandemic. This includes active collaboration with the Washington Department of Agriculture to assess impacts on food processing and distribution, and to develop response mechanisms. One highlight of this effort is the creation of a mobile meat processing lab that can be used to address the shortage of meat animal processing capacity/opportunity – especially for small producers.

WSU Extension also piloted and evaluated in Washington (October through December) a "Remote Worker" training program currently offered by Utah State University (USU). Extension will be fielding that training in a co-branded collaboration with USU and the Association of Washington Businesses. The program provides training on the basic "soft" and technical skill sets necessary to be a successful remote worker and issues a certificate which is a meaningful qualification for un/under-employed job seekers. Two of the participants in the pilot cohorts have already found good remote work employment.

Impacts of the Pandemic on the Nation's Public and Land-Grant Universities

While the nation's research universities have risen to the challenge and are responding effectively to the pandemic, there remain significant short- and long-term impacts to the nation's university research enterprise. As discussed above, overall output at research intensive universities is estimated to have declined by approximately 20%-40% from the period of March 2020 through March 2021. COVID-19 has impacted faculty members, postdocs, technicians, and graduate students in numerous ways, including student educational progress, career development of faculty and staff, work-life balance, the development of collaborations and partnerships, and immigration status. COVID-19 has also had the unfortunate effect of exacerbating pre-existing gender, racial, and other inequalities.

Financial, operational, and related impacts to institutions

The nation's public and land-grant universities very much appreciate the support Congress has provided via the CARES Act and other means. Since the start of the pandemic, Congress has provided $37 billion to support students and institutions of higher education across the country. WSU has received $21.76 million and recently received an additional $34.9 million for a total of $56.66 million. WSU has aided almost 11,000 students system-wide and every dollar Congress has provided to students has been allocated to support their needs during the pandemic.

While Congressional support has been very helpful, the pandemic has nonetheless impacted university finances, infrastructure, and the ability of our public and land-grant universities to pursue their missions generally. Over the last several years, U.S. colleges and universities have become increasingly dependent on tuition and student fees as state appropriations for higher education have significantly declined over time. COVID-19's disruptions to traditional instructional models, to international students, and to the economy are all producing significant financial shortfalls for universities, with smaller universities more heavily reliant on tuition the most affected.[6] At WSU, for example, system-wide additional costs attributed to the pandemic through December 31, 2020, have

[6] APLU estimates of pandemic related costs and revenue loss are available at https://www.aplu.org/members/councils/governmental-affairs/CGA-library/aplu-97b-heerf-request-and-justification/file

totaled nearly $6.1 million. Simultaneously, WSU has lost revenue as a result of the pandemic. In September 2020, WSU forecasted a $105 million drop in revenues from state appropriations, tuition, housing, dining, and other auxiliary units in FY2021. These revenue reductions are partially offset by associated reduced expenses, leading to a projected net revenue loss of $54M.

According to an APLU member survey designed to ascertain the level of institutional expenses and losses due to the pandemic, APLU members saw a total of $20.8 billion in revenue losses and expenses related to safety measures. This included $6.5 billion in revenue loss for spring and summer, $11.2 billion revenue loss for fall, and $3.1 billion in expenses for safety measures. To help fill the funding gaps, Congress provided APLU institutions with $1.7 billion in CARES Act and $4 billion in the Coronavirus Response and Relief Supplemental Appropriations (CRRSA) Act funding for institutional expenses and losses. Even with the $5.7 billion in Congressional support, the 199 public research universities that comprise APLUS's membership collectively face a $15.1 billion funding gap as a result of the pandemic.

Institutions of higher education have also seen increases in costs associated with public health measures such as testing, cleaning procedures, as well as urgent investments to support online instruction. According to an APLU member survey, APLU institutions have spent over $3.1 billion on safety measures including COVID-19 testing and contact tracing, face masks, cleaning, and operating quarantine dorms through the spring and fall 2020 semesters. In response to unavoidable costs, revenue reductions, and forecasts of declining revenues, many universities found themselves having to reduce other expenditures across the board to strengthen their finances. This included hiring freezes, often on an institution-wide basis. Substantial research support services – everything from academic libraries and research cores to laboratory safety and research security compliance – are funded by a combination of grant overheads and general appropriations. In this sense, the fully loaded cost of sponsored, or externally funded, research is not fully covered by grant awards, and this was exacerbated by the pandemic due to the need to purchase personal protection equipment (PPE) and other costs. As a result, universities must cover sponsored research costs from other sources.

The nation relies on its universities to train the next generation of researchers and scholars essential to functioning of the "innovation pipeline" that translates fundamental research advances to achievements that benefit the lives of our people every day. Financial impacts associated with the pandemic have significantly impacted hiring and staffing, with short- and long-term impacts to the innovation pipeline. In particular, more than 300 U.S. universities and colleges announced hiring freezes, in some cases even rescinding offers that had already been made. According to the Science Careers Job Board, faculty openings in the sciences were down approximately 70% in 2020. Many of these individuals have sought employment elsewhere and will be permanently lost from academia.

The ramp-down of laboratories and laboratory-based scientific research activities not only impacted research progress and projects, it also added pressures around internal costs and core facilities. Even if salaries and benefits continued to be paid uninterrupted, as other direct expenses such as travel, equipment, or materials were unspent, universities still had to pay for many of the expenses to support research equipment, personnel, utilities, and other costs that may have been covered by allowable indirect costs charges related to federal grants. But without research activities campuses could not recover these operational costs. These losses contribute to budget shortfalls at many institutions.

The impacts of the pandemic on core university laboratories has been significant. Universities typically support widely used research instrumentation in areas such as genome sequencing, microscopy, and magnetic resonance imaging through a combination of internal funding and use charges. These core laboratories also rely heavily on user fees from faculty, staff, and students directly engaged in research. The reduction in on-campus research has thus directly impacted these core facilities, leading to loss of key support staff and physical infrastructure. At the University of California Los Angeles, the School of Medicine lost $3 million per month supporting their core facilities before they began to slowly ramp-up in the spring. At WSU, the overall core lab business from WSU customers was down by approximately 25% in 2020.

The pandemic also essentially eliminated research-related travel, including the ability to conduct numerous types of agricultural and other field research. Loss of seasonal data and specimens has delayed research by at least a year, and in the case of specimens requiring longer generation times, even more. The situation is particularly concerning for students and early-career researchers. Travel restrictions also directly inhibited some types of collaborative research requiring investigator presence. Scholarship and creativity in the fine arts is also largely on hold due to closure of venues.

Impacts on particular types of institutions and communities

Many students at smaller, public institutions are low income, minority, or first generation students. These underserved students have either limited or no opportunity to engage in research. This is discussed in detail in a January 2021 report entitled "Building America's STEM Workforce: Eliminating Barriers and Unlocking Advantages.[7]" The report states: "Historically, the majority of federal research funding has been distributed to a fraction of our country's research universities. In 2018, for example, of the more than 600 colleges and universities that received federal science and engineering funding, approximately 22% received more than 90% of federal science and engineering funding while only serving 43% of all students and 34% of the nation's underrepresented minority (URM) students. This discrepancy results in students at the approximately 500 remaining colleges and universities, including almost two thirds of the nation's URM students and more than two thirds of Pell grants recipients, having either limited or no opportunity to engage in research."

In addition to having very limited research opportunities, these underserved students are also far more susceptible to the negative educational and financial consequences of COVID-19. As these universities are left out of COVID-19 opportunities for vaccines, testing, and grants, it amplifies existing workforce and other inequities.

Faculty, especially assistant professors, at smaller institutions struggle to compete effectively for federal funding against their counterparts at larger institutions with more resources and better infrastructure. COVID-19 exacerbates this issue. Overall, lower university resources at smaller institutions prevented wide-scale COVID-19 testing and vaccination, and thus, inhibited return to research activity. Many professors had additional teaching commitments due to the increased number of classes arising from enhanced student-to-student distancing requirements. Since having smaller research portfolios generally translates to higher teaching loads, these impacts were likely higher at institutions with less research funding. Institutions with smaller research portfolios often do not have resources to invest in rapid response research projects while many larger institutions were able to fund such projects internally. Additionally, NIH adopted a "fund the funded" approach to COVID-19 response,

[7] https://www.aps.org/policy/analysis/upload/Building-America-STEM-workforce.pdf

blocking many smaller programs from new or expanded funding opportunities and continuing the trend of undue concentration of federal funding. Therefore, smaller federal funding portfolios means less likelihood of getting federal dollars for research relief assuming relief is based on current funding levels.

Historically Black Colleges and Universities (HBCU) have proven to be extremely effective in graduating Black students, particularly in STEM areas. HBCUs represent less than 3% of colleges and universities in the U.S., but they confer 40% of all STEM degrees and 60% of all engineering degrees for Black students. Additionally, according to the National Science Foundation, the top ten baccalaureate institutions that produce Black students who go on to earn doctoral degrees in science and engineering were, except for one institution, all HBCUs. One of the deciding factors in acceptance to graduate programs is previous research experience, and STEM students at HBCUs are engaged in research at a higher rate than Black students at predominantly white institutions.

While HBCU's award a high fraction of STEM degrees to Black students, their research and development expenditures are slightly less than 1% of the U.S. Higher Education Research and Development expenditures. This stark difference is a major factor driving the relatively low presence of Black scientists and researchers in STEM fields. The pandemic has only highlighted this and other inequalities. For example, the relatively low fraction of research and development expenditures at HBCUs has undercut their ability to handle additional costs associated with the pandemic.

The pandemic has intensified an already challenged training environment for HBCU STEM students and faculty. HBCUs generally operate with resource limitations, which necessitate having teaching and research personnel with high workloads operating with often outdated infrastructure and technologies. The impact and significance of the STEM graduates produced and overall research competitiveness can only grow and expand exponentially with enhanced capacity building through strategic investments in these institutions. To be impactful in driving qualitative outputs and scholarly productivity in HBCUs, one consideration is to invest in the building and maintenance of state-of-the-art core laboratory infrastructure in the STEM training environments. In addition, support is needed for a series of strategic personnel hires to ensure cultivation of a critical mass of highly qualified faculty – with an eye toward building and retaining interdisciplinary and collaborative research teams to drive research enterprise at small- and medium-sized institutions.

Across the nation, numerous studies have shown that women researchers are most impacted by pandemic. This is because women form the majority of caregivers for children and elders. Additionally, a greater proportion of women scientists than men scientists are in temporary or insecure employment such as adjunct posts in which they may only be paid when teaching courses. As a result, the pandemic has highlighted the vulnerability of women researchers who are trying to manage work-life balance, while shouldering the bulk of the domestic and family responsibilities. A January 2021 National Bureau of Economic Research (NBER) study[8] with over 20,000 Ph.D. respondents indicated that women academic researchers lost roughly double the daily time devoted to research compared to male academics. The trends are accentuated for academics with younger children, especially pre-tenure women with children. This will have long lasting impacts on the career trajectory of women faculty. The burden or homeschooling and lack of childcare is impacting women researchers more than men. Without childcare or school, women researchers are less able to do field work. Additionally, the overall impact on field work has been severe with the reduction in undergraduate assistants. Time-sensitive

[8] As reported by Science magazine- see https://science.sciencemag.org/content/371/6530/660.summary

experiments are not able to be done. Nature (December 2020) reported that publications in all areas have surged, but men have led women in submissions, particularly in the life and health sciences.

Ramp-downs and remote working have affected outputs of laboratory-based researchers, including enhancing existing inequities in allocation of laboratory space to women researchers. Due to personal circumstances, more women researchers than male researchers have had to work remotely for longer. Time spent at the bench impacts the pace at which publishable data are acquired by women compared with men; fewer women in the lab translates to lesser number of publications with women first author contribution; and it leads to a decline of the women academic pipeline, which will have long-term impacts. This disproportion will also impact the career profiles of male and female scientists differently over the years to come. The effect of the pandemic will be found in the future job market gender profile and employability by gender, not because of gender bias per se, but because of greater academic outputs imbalance than was previously observed before the pandemic. This will not be limited to the academic settings.

Women leave academia earlier than men, leading to a perceived male-dominated output environment, even though the scientific outputs compared to gender and average year are found to be on par with pre-COVID-19 scientific outputs. This is likely to change since a larger proportion of academic female researchers than male researchers have either chosen or had to choose another career outside academia, further shortening the average academic life of women and limiting their contribution to scientific knowledge. Alternatively, those who have chosen or been able to remain in position as laboratory researchers will be more likely to have less scientific outputs and thus, be less competitive on the job market than their male counterparts. Further, the negative impacts to females in academic roles is likely to have long-term negative impacts on the quality and quantity of education and research unless the situation is actively addressed.

Functional networking has also been affected, both internally and externally. In-person networking through conferences, as well as increased visibility at conferences through invited talks, have been challenged. This impact is yet to be investigated. Regardless, it is easier to network in person at a conference than to email a stranger who has given a talk online viewed by many and to whom questions asked were filtered and delivered anonymously. At a conference, question and answer sessions are one of the recognized opportunities for women scientists to make themselves known and engage with experts in the field. The unconscious bias that junior scientific women have against putting themselves out there compared to their male counterparts will be further worsened by the remote-conferences structure. It would be imperative to monitor how remote conferencing has impacted networking from a gender perspective, as it is likely to greatly impact the career progression and job market opportunities of women more than men.

For early-career scientists, the disruptions have made it increasingly challenging for them to complete necessary research and to advance their careers. The slowed research progress also indicates legitimate concerns about career trajectory for early-career scientists, including those with caretaker responsibilities. As a result, many institutions are adapting their tenure and promotion processes to account for some of these impacts. Due to the unprecedented impact of COVID-19, some institutions, including WSU, the University of Washington, Ohio State University, Penn State, and Florida State University, made the decision during the last academic year to pause their tenure and promotion clock for one year. Several early career scientists who have yet to achieve stable external funding were forced to use start-up packages to pay for the costs associated with the pandemic.

Graduate students are facing similar challenges as faculty members during the COVID-19 pandemic but are receiving fewer assurances. In the spring of 2020, countless graduate students watched their education modality change overnight, putting degree timelines in question. Furthermore, these students worry about losing the external and university funding that supports their research. Prospective graduate students are experiencing major disruptions to the entrance exams, application, and admission process. Graduate student cohorts are shrinking in some fields as universities put school-funded Ph.D. programs on pause due to the fiscal constraints for 2021-2022. As of October 8, 2020, more than 108 doctoral programs across the country concentrated in the humanities and social sciences are not admitting new students in the fall of 2021. The reasoning behind these pauses is to ensure that there is enough funding for current school-funded Ph.D. students. Moreover, graduate students are not able to interact and connect with senior scientists at virtual conferences as effectively in a remote environment which will negatively impact their career growth.

Professional students in programs such as medicine, nursing and pharmacy have also been dramatically impacted by the pandemic. Similar to other students, their didactic face-to-face curriculum changed almost overnight. They experienced limited access to campuses for their clinical skills development and intermittent and unpredictable access to the experiential learning clinical settings. Further, they have been impeded by the inability to take board examinations (e.g. boards examination for medical students that are critical for residency placements) or to complete many of the requirements for degree completion. The cumulative impact for our professional students has included financial impacts, slowed progress to degree completion and uncertainties regarding the changes in the professional field of practice. As an additional point, the professional students associated with the WSU Health Sciences program have significantly increased service activities involving patient care, vaccination, and overall volunteerism. This has been inspirational. As an example, pharmacy and nursing students at WSU Spokane are actively engaged in local vaccination efforts.[9] Spokane residents being vaccinated will often find a WSU student "on the other end of the needle."

Additionally, there may be selected financial impacts for STEM graduate students. Some are dependent on teaching assistantships for their stipends, but the availability of teaching assistantships for laboratory courses at many universities dropped in spring 2020 due to the ramp-down. Additionally, doctoral students are facing delays from disruptions to laboratory and field research, which may slow their degree progress. Some may no longer be on track to graduate within the time frame that external or university funding typically covers. These students may need extensions to their degrees, possibly to their grant funding, in order to complete their dissertations.

While all students are facing issues with research due to pandemic-related shutdowns, international graduate students and postdocs are facing a unique set of challenges. The biggest concerns for international students and researchers revolve around the ability for them to join, or rejoin, the U.S. academic research community. The global pandemic's travel disruptions coupled with immigration and visa-related challenges may result in fewer international students and researchers coming to the United States. These are significant concerns as international students make up more than one third of the total U.S. graduate enrollment in science and engineering.

The effects of the pandemic and current visa restrictions on WSU graduate students have been pronounced. WSU's 1,150 international graduate students represent about half of the graduate student population. Due to the pandemic and immigration restrictions, about half of the international student

[9] See https://www.spokesman.com/stories/2021/jan/26/rise-to-the-challenge-wsu-nursing-pharmacy-student/ .

cohort has returned home, in many cases delaying their career progress. Furthermore, approximately one-third of newly admitted graduate students have deferred admission.

WSU international graduate students have also faced numerous funding concerns. Students returning home cannot stay on assistantships even if they stay enrolled- leading some to terminate their studies. Funding for those students remaining in the US has dropped as research grants have paused work, and teaching assistantships have decreased due to lower enrollments and departmental financial constraints. COVID-19's economic impact has also decreased the amount of funding available from international students' home countries. In many ways, there is a "perfect storm" financially for international graduate students. At WSU, regrettably, we have stories of international graduate students struggling to pay even minimal food and utility bills.

The research enterprise is at risk of losing a whole cohort of graduate and post-doctoral students seeking training and education, which includes researchers from underrepresented groups, minorities, women, and junior researchers. This will have profound and long-lasting impacts on both the research workforce and the research portfolio. Understanding this and other associated pandemic impacts is paramount to maintaining America's global competitiveness, technological leadership, and the economy of the United States.

Looking Ahead – Transition to the "New Normal" and Congressional Support

It is clear that the research enterprise within U.S. colleges and universities has been through a major disruption. But even during the crisis, university researchers have continued to forge ahead and pursue knowledge and discovery. The examples highlighted today showcases the importance of research to both address the current pandemic and other challenges facing society. There will be future pandemics, however, and now is the time learn from our COVID-19 experience and plan accordingly. This will require significantly more investment in research and development as well as our associated research and public health infrastructure. At the same time, the U.S. maintaining its position as a world-leading innovator requires the nation to continue to invest in a broad range of current and emerging fundamental, applied, and developmental research opportunities. As we have seen with COVID-19, this work will be increasingly interdisciplinary, requiring a well-planned portfolio approach to the nation's research investments.

The increasingly interdisciplinary nature of modern research highlights the importance of collaboration, including international participation in the nation's research enterprise. In particular, international scholars and students play a vital role in advancing discovery and innovation at the nation's research universities. Travel and visa policies should be examined and modernized to support collaboration and exchange of ideas. APLU universities are committed to performing these collaborations in a safe and secure manner consist with federal guidance.

As we recover from the pandemic, a new pandemic normal for how research is conducted will emerge. How we conduct research in the new pandemic normal will look different than prior to the pandemic. While this can seem daunting, it also presents us with opportunities to look at new paradigms and models that will better serve the research enterprise throughout the 21st century.

For example, remote work and learning has exposed the need for universities and colleges to rethink how we do research and the role that virtual tools and platforms may play in the search of knowledge. Researchers are making great progress in this area already. The "Robotarium" at Georgia

Tech[10] allows thousands of faculty and students (and non-researchers as well) to remotely test their robotics control programs in a controlled, safe environment. Other possibilities under investigation include fully remote research laboratories (including virtual reality headsets and motion sensing gloves controlling artificial intelligence (AI) lab robots), fully remote meetings with three-dimensional virtual objects manipulatable by attendees, and "classrooms without walls" including, for example, the ability to manipulate complex data sets in three dimensions. Many of these opportunities will be realized thanks to the coming revolution in artificial intelligence.

Indeed, the pandemic has highlighted the rapidly emerging role of AI in conducting research. In March 2020, The Allen Institute for AI (AI2) created a machine-readable COVID-19 dataset incorporating published COVID-19 research results. The AI2 developed an initial capability, known as CORD-19, in ten days. CORD-19 now incorporates over 280,000 scholarly articles. This machine learning capability allows individuals, including researchers, to directly ask questions related to COVID-19 and obtain answers based on the results of these 280,000 articles. This is a fascinating demonstration of the power of AI and machine learning, and a window into the major changes AI will bring to the nation's research enterprise.

I thank Chairwoman Johnson, Ranking Member Lucas, and other members of this committee for sponsoring the Research Investment to Spark the Economy, or RISE, Act, which would provide $25 billion to federal agencies to support independent research institutions, public laboratories and universities throughout the country to continue work on thousands of federally-backed projects impacted by the COVID-19 pandemic. The funding would also be used to support early-career researchers and graduate students, researchers in disciplines not fully recovered (such as human subject research and fieldwork), and vital facilities.

In particular, these funds will help mitigate the increased costs of doing research associated with the pandemic. Research, particularly laboratory and experimental research, costs more to conduct and takes a longer time to complete due to personnel and operational constraints associated with COVID-19. Many of these costs, such as those associated with infrastructure, are expected to persist as we prepare for the next pandemic event. The RISE Act funds will also be used to mitigate many of the inequalities dramatically exposed in the current pandemic. This includes gender and racial inequalities, as well as the weaknesses in research infrastructure present at our research institutions, particularly so at smaller and HBCU institutions. Finally, the RISE Act funding is essential to help address the long-term reduction in support for federally funded fundamental research. This long-term trend, which threatens the U.S. "innovation pipeline," has been discussed frequently within Congress and is very familiar to you.

Additionally, APLU is grateful for your joint leadership in introducing the Supporting Early-Career Researchers Act on January 5, 2021. This legislation would create a new postdoctoral fellowship program at the National Science Foundation to support early-career researchers whose opportunities have been affected by the COVID-19 pandemic. This act should also acknowledge and mitigate the impacts arising from changes in traditional career paths.

Both pieces of legislation are critical to the prevention of loss of research and talent due to any economic disruptions that may have occurred due to the public health emergency. Research universities and colleges across the nation play a critical role in the recovery of the pandemic. That is why investing in our academic research institutions is so vital. The growth of the U.S. economy and our leadership

[10] See http://www.robotics.gatech.edu/robotarium.

around the world depends on our nation's continued ability to lead in scientific discovery and technological innovation.

Without supplemental research funding, the contributions of research universities and hospitals to America's health, economy and national security will be impaired for a long time to come. Relief is needed to allow federal agencies to provide research grant and contract supplements (i.e., cost extensions) for expenses arising from COVID-19-related impacts; emergency relief to sustain research support personnel and some base operating costs for core research facilities and user-funded research services; and support for additional graduate student and postdoc fellowships, traineeships, and research assistantships to allow early-career scientists to complete degrees and enter the workforce rather than leaving science and engineering altogether.

Failure to provide this funding now will force federal research agencies to make difficult decisions between funding the completion of existing research projects or funding new projects. Some federal agencies are already planning for this possibility. Rescuing the nation's scientific research enterprise and supporting new research should not be an "either-or" choice – both are vital to our nation's health, security, and economic competitiveness and recovery.[11]

Conclusion

APLU and its member institutions very much appreciate the strong support provided by Congress during the pandemic. It has allowed the nation's public and land-grant universities to "rise to the challenge" and play critical roles in supporting their communities, states, and the nation in the campaign against the coronavirus. In short, the nation's universities remain more dedicated than ever to their core missions and supporting the people of our nation.

The pandemic has unfortunately also highlighted existing gender, racial, infrastructure, and other inequalities and challenges within our university research system. It is also clear that the "new normal" following the pandemic will differ substantively from life in the "before time."

It is imperative that APLU, similar organizations, and university leaders work closely with public and private sector colleagues to address these challenges and develop a robust vision and plan for supporting our nation's public and land-grant research universities following the pandemic. The health of the nation's research ecosystem – and the innovation and enhanced quality of life that arises from it – are at stake.

Finally, we are grateful for the committee's leadership in exploring the impact of the pandemic on our nation's research institutions and for your support of the RISE Act and the Supporting Early-Career Researchers Act. Continued Congressional support for federal research agencies is essential for national recovery from the pandemic and transitioning the nation's research enterprise to the "new normal," which assuredly will not look like the situation pre-pandemic. The nation relies on its

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[11] AAU/APLU/AAMC/ACE Association letter to Congressional Leadership 1/26/21 – (https://www.aplu.org/members/councils/governmental-affairs/CGA-library/associations-letter-supporting-26b-research-relief-request/file)

universities to train the next generation of researchers and scholars essential to functioning of the "innovation pipeline" that translates fundamental research advances to achievements that benefit the lives of Americans every day.

I am grateful for this opportunity to offer this testimony today. Thank you.

WASHINGTON STATE UNIVERSITY | External Affairs and Government Relations

CHRISTOPHER J. KEANE, Ph.D.

Vice President for Research

Professor of Physics

Christopher Keane is Vice President for Research and Professor of Physics at Washington State University. He received a B.S. degree in Physics and Engineering, Magna Cum Laude, from the University of Rochester in 1980. He received his Ph.D. in Astrophysics from Princeton University in 1986. Dr. Keane then joined the Inertial Confinement Fusion Program at Lawrence Livermore National Laboratory (LLNL), performing computational and experimental research in x-ray lasers, inertial confinement fusion (ICF), and ultra-high intensity laser–matter interactions.

Dr. Keane joined the U.S. Department of Energy in 1996 as the Associate Director of the Office of Inertial Fusion within the Office of Defense Programs in what is now the National Nuclear Security Administration (NNSA). He held several leadership positions at NNSA, ultimately serving from 2004-2007 in the Senior Executive Service as Assistant Deputy Administrator for Inertial Fusion and the National Ignition Facility (NIF) Project. In this latter position, Dr. Keane was responsible for the NNSA ICF Program, including construction of the $3.5 billion NIF laser. He also worked closely with NNSA, Office of Science, and Office of Science and Technology Policy leadership to establish programs aimed at advancing the study of fundamental high energy density science. This includes the NNSA/Office of Science Joint Program in High Energy Density Laboratory Plasmas. This program now supports a large fraction of the U.S. researchers involved in this rapidly evolving and exciting area of science.

Dr. Keane rejoined LLNL in 2007 and went on to serve as director of the NIF User Office from 2009 through June 2014. In this role he worked with LLNL, Department of Energy, and other leaders to launch the NIF user program. This successful program allows academic and other users to conduct astrophysics and other experiments aimed at using the football-stadium sized NIF's unique capability to examine the behavior of matter at extreme pressure. Dr. Keane also served in 2014 as Acting Deputy Principal Associate Director for Science and Technology within the LLNL NIF and Photon Sciences Directorate.

Dr. Keane joined Washington State University in 2014. He has taken significant steps to reshape the University's research enterprise. Dr. Keane spearheaded the 120-day study identifying WSU's areas of research excellence and areas where operational improvements were needed. He led WSU faculty and staff in articulating "grand challenges" – institutional multidisciplinary research areas that focus on urgent regional, national, and global problems. The grand challenges effort resulted in the funding of four focused research initiatives that have yielded an approximate 17x financial return in terms of

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awards received. He has also led major operational improvements to the WSU Office of Research. This included enhancing performance and efficiency of offices overseeing animal and human subject experiments, commercialization and industrial engagement, proposal submission and award, and other services essential for supporting faculty and staff engaged in the research enterprise. WSU has recorded record research expenditures in the past several years under Dr. Keane's leadership.

Dr. Keane also has significantly strengthened the partnership between WSU and the Pacific Northwest National Laboratory (PNNL), launching three WSU-PNNL Joint Research Institutes as well as programs supporting Ph.D. research at PNNL for WSU graduate students and joint research appointments for PNNL staff and WSU faculty. He serves on the Board of Directors for the Pacific Northwest National Laboratory.

Dr. Keane is a Fellow of the American Association for the Advancement of Science and a member of the American Physical Society. He is the recipient of the NNSA Silver Medal, the Defense Programs Award of Excellence, and the Fusion Power Associates Special Award. He has also served on several major national and international advisory and review committees, including the DOE Fusion Energy Sciences Advisory Committee, the United Kingdom Fusion Advisory Board, and most recently the Los Alamos National Laboratory Complex Natural and Engineered Systems Review Committee. He has authored more than 100 scientific publications.

In 2018, Dr. Keane was elected to membership in the Washington State Academy of Sciences, an organization that advances science in the state and informs public policy.

Dr. Keane was elected as a member of the Association of Public and Land Grant Universities Council on Research Executive Committee in 2016. He was elected Chair of the APLU COR in summer 2020, with his appointment lasting through mid-November 2021.

Chairwoman JOHNSON. Sorry I didn't unmute. Thank you very much for your testimony. Dr. Levine.

TESTIMONY OF DR. FELICE J. LEVINE, EXECUTIVE DIRECTOR, AMERICAN EDUCATIONAL RESEARCH ASSOCIATION

Dr. LEVINE. Thank you very much, Chairwoman Johnson, Ranking Member Lucas, and Members of the Committee. I appreciate the opportunity to speak with you today.

As we reach the 1-year mark of COVID–19 hitting the United States with full force, the disruptions to the lives of early career scholars and doctoral students in higher education institutions have proven to be drastic, persistent, and far-reaching. The harsh conditions are taking their toll on research progress, research, researchers, and academic careers, as my colleagues have just also addressed. It also exacerbated gender and racial inequities that may have long-lasting effects on future generations of researchers.

Almost at the onset of the pandemic, scholars of the American Educational Research Association and the Spencer Foundation determined that it was essential to use our research expertise to gather information about the experiences and needs of early career scholars and doctoral students. We decided to undertake two studies, the Focus—the COVID–19 Focus Group Study, and the COVID–19 Impact Survey. The Focus Group Study report was just released in late January and is based on systematic study of 12 focus groups of early career scholars and doctoral students. We were able to hear their voices. The survey is a national study of some 6,000 doctoral students and early career scholars engaged in education research. The data collection just ended several weeks ago, and data analysis is about to begin.

Today, I share just a handful of topline findings and facts that are prototypical of our results, along with other studies noted in my written testimony. They convey a reality that those committed to scientific progress, U.S. science leadership, inclusive scientific literacy, and diverse workforce must confront.

First, we learned from our focus groups that scholars are facing research derailments and delays, uncertainties, and ambiguities. This finding is consistent with our survey data. Approximately 70 percent of both early career scholars and doctoral students said COVID–19 had substantially slowed progress on critical research tasks, 45 percent of the doctoral students reporting extending their doctoral completion day as one indicator of the impact of those delays.

Second, systemic racism in particular after the killing of George Floyd has led to a dual pandemic and added professional pressures for scholars of color. They are experiencing not only emotional distress and exhaustion compounded by being asked to take on more work to help their institutions address these issues. And we need to understand how to strike a balance in that arena.

Third, scholars, especially women, face uncertainties and barriers to research productivity while juggling family and home. This theme was dominant in both focus groups and the survey. Seventy percent of female doctoral students and 74 percent of female scholars with childcare responsibilities reported a significant increase due to COVID–19 of these responsibilities.

Fourth, researchers are increasingly concerned about their employment status and careers. Our survey data show that nearly 24 percent or a quarter had already reported experiences of reduction or loss of income due to COVID–19.

Fifth, scientific progress, as we know, depends upon three C's and a lot of A's of course, cumulative knowledge, collaboration, and connection. Yet another dominant focus group theme and survey result is a loss of opportunities for collegial exchange. Forty-six percent of the doctoral students and 57 percent of the early career scholars reported a great deal of loss, and over 80 percent of both groups referred to the absence of that kind of exchange and interaction as affecting and shaping their careers.

However stark these data are, findings like these are helpful for the work that you are doing. Together, we have an opportunity to do better. AERA and our peer associations strongly support the *RISE Act*. It would provide a much-needed infusion of funds to address the cost of disruptions to research grants, provide financial support and flexibility for researchers, and help cover expenses to ramp research back up.

AERA also strongly endorses the *Supporting Early Career Researchers Act* for all the reasons set forth by the Members and also from my colleagues. It will establish a new National Science Foundation (NSF) fellowship program to help early career researchers in the STEM pipeline in flexible and appropriate and essential ways.

We are at a pivotal time to support the next generation of researchers and the research enterprise that relies on them. The risk to their futures and to our country that reaps the benefits from science are far too great to miss this opportunity.

Thank you, and I look forward to participating in the question-and-answer session that follows.

[The prepared statement of Dr. Levine follows:]

The Impact of COVID-19 on Early Career Scholars and Doctoral Scholars

Testimony provided to the
United States House of Representatives
Science, Space, and Technology Committee

February 25, 2021

Felice J. Levine, PhD
Executive Director
American Education Research Association

Chairwoman Johnson, Ranking Member Lucas, and members of the Committee, thank you for the opportunity to speak with you today.

As we near the one-year mark of COVID-19 hitting the United States in full force, the disruptions to the personal and professional lives of early career scholars and doctoral students at universities and colleges across the country have proven to be drastic, persistent, and far-reaching. The harsh realities of the pandemic and its impact on social institutions like school, work, and the family have created challenging conditions that are taking their toll on research progress, researchers, and academic careers. These conditions have also exacerbated gender and racial inequities that may have lasting effects on future generations of researchers and the production of research.

Soon after the onset of the pandemic, the American Educational Research Association and the Spencer Foundation launched a two-part project to assess the pressing needs facing early career scholars and doctoral students and ways to address those needs. I want to acknowledge the team of eight affiliated with these two organizations and my collaborator, Dr. Na'ilah Suad Nasir, Spencer Foundation President. All bring commitment, caring, and extraordinary competence to undertaking this work during this pernicious pandemic time.

Simply put, we were very much concerned with the well-being and career trajectories of early career scientists and how the continued production of knowledge might be stalled, attenuated, or worse by adverse impacts on those who are at the beginning stages of their careers. We were determined to provide information to help higher education leaders, private and public funders, policymakers, and other organizational heads better support the next generation of researchers and to learn about immediate as well as far ranging effects with consequences for the nation's research enterprise.

The COVID-19 Focus Group Study consisted of 12 focus groups held in late May and the beginning of June 2020. The groups were held via a video meeting, were recorded, and the video data and transcriptions (a total of 18 hours of group interaction) were

systematically examined. The second part of this research—the COVID-19 Impact Study—is a national web-based survey of approximately 6,000 early career scholars and doctoral students. Developed by AERA and the Spencer Foundation, NORC at the University of Chicago fielded the survey on our behalf. The data collection was completed at the end of January.

This testimony is based primarily on the focus group study and the report released in January 2021—*Voices from the field: The impact of COVID-19 on early career scholars and doctoral students*. The report includes emphasis on the voices of participants through substantial reliance on their own words. What we heard during these group discussions drove home the severity of the pandemic's impact on the lives and careers of these scholars. The analysis led to identifying seven major themes.

1. **Research Has Been Disrupted and Delayed, and Scholars Are Having to Adapt** – Scholars are facing derailments and delays in research projects. Their normal access to school administrators and students has been curtailed. As education across levels and contexts has changed drastically and quickly, research projects are undergoing rapid change as well. Researchers are facing uncertainty and ambiguity in their research projects in this unpredictable, ever-shifting environment.

2. **The Emergence of Systemic Racism Has Created a Dual Pandemic and Additional Professional Pressures** – The emergence of a dual pandemic, after the killing of George Floyd, heightened concerns about systemic racism and institutionalized inequities in society. Scholars of color are experiencing emotional distress and exhaustion from being asked to do even more work, such as supporting students of color, teaching courses on race, or being the "go-to" person when racism and police brutality became more visible.

3. **Scholars Are Struggling to Balance Family, Home, Community, and Professional Life** – Scholars, especially women, face uncertainties and barriers to research productivity while juggling home and family challenges, including providing full-time childcare and helping young children struggling with the social and educational challenges of virtual learning. They are not only concerned about their personal challenges, but those of their colleagues and students.

4. **Researchers Are Uncertain about Job Security and Career Opportunities –** Researchers are increasingly concerned about their employment status and career trajectories as the result of deep budget cuts, falling enrollment, and the elimination of programs at institutions nationwide.

5. **There Is a Growing Sense of Disconnection and Lost Community** – The pandemic has affected researchers' sense of connection to colleagues. Many feel they do not have the resources or bandwidth to stay professionally engaged, impeding future research collaborations. Doctoral students in particular worry about diminished opportunities for creating networks to support their job search.

6. **Researchers Are Concerned about Institutional Incapacity to Respond and Support** – While some scholars appreciate what they view as sincere efforts by institutions to support them, few see leadership as attuned to their situations. Many experience responses from institutional leaders as bureaucratic or as attempting to perpetuate a sense of normalcy when the circumstances are anything but normal.

7. **Online Teaching Is Creating Uncertainty, Complexity, and Heightened Concerns about Inequity** – COVID-19 is adding extra layers of responsibility and uncertainty to scholars' teaching and mentoring roles. While some have seen opportunities in the shift to online learning, others are deeply concerned about the inequity issues caused by technology access and online participation.

The findings summarized above and set forth in detail in the report underscore the serious challenges we face in ensuring that scholarly fields and institutions of higher education retain and foster an inclusive talent pool of research excellence. The report offers a series of recommendations relevant to this hearing. Among the most germane are to: provide funding that allows for material support to emerging scholars (both salary and "soft support"), build community and connect scholars, support scholars with caregiving responsibilities, and focus on mentoring.

As noted earlier, the data collection for the AERA-Spencer COVID-19 Impact Survey concluded just weeks ago. Work is now underway to allow for appropriate weighting of the data and preparing for the data analysis. The study includes 3,339 early career doctorates and 2,642 doctoral students. With the caveat this information is preliminary, I want to thank Tom Hoffer at NORC for working rapidly with me to offer some brief facts-at-a-glance relevant to the focus group report and the committee's work:

For doctoral students:

- 45% of the doctoral students indicate that COVID-19 has extended the timeline for completing their doctoral degree; 33% noted that they have experienced a great deal of delay in completing their doctoral degree.
- 73% of the doctoral students indicated increased stress related to working on doctoral studies remotely (some increase by 31%; a great deal of increase by 42%)

- 80% cited reduced opportunities for collegial exchange as either a great deal (46%) or some (34%) source of difficulty.
- 69% believed COVID-19 has substantially slowed their progress on critical research tasks with 35% indicating very significant and 34% moderately significant impacts.
- 48% of male and 46% of female doctoral student respondents have childcare responsibilities; 70% of the women with childcare responsibilities report a significant increase in those responsibilities due to the pandemic, compared to 55% of their male counterparts.

For early career doctorates:

- 24% have experienced a reduction or loss of wages, hours worked, or other income from employment as a result of COVID-19; 21% view it as very likely (14%) or likely (7%) that they will experience such a reduction or loss in the next 12 months.
- 72% have experienced stress related to working remotely from home: 33% a great deal of stress and another 39% some stress.
- 87% have experienced reduced opportunities for collegial exchange: 57% a great deal and 30% some reduction.
- 71% report COVID-19 has substantially slowed progress on critical research tasks (37% very significant; 34% moderately significant).
- 56% of women and 61% of men have childcare responsibilities; 74% of women and 67% of men report a significant increase in those responsibilities related to the pandemic.

A survey of 329 high energy physicists focused on the impact of COVID-19 (undertaken at about the same time as our Focus Group Study) revealed similar thematic concerns. Hildreth and Narain (2020) reported that physicists indicated that their efficiency is lower working from home; isolation is widely felt; and childcare is affecting how graduate students, postdocs, faculty, and others spend their time. See https://science.osti.gov/-/media/hep/hepap/pdf/202007/07-Hildreth_Narain-Community_Gathered_COVID-19_Impacts_for_HEP.pdf?la=en&hash=F6FE69EFB66A99207380F4286B3AB94185CEAB8A.

These results further complement the results of a survey undertaken in summer 2020 of 208 senior university officials that oversee graduate education. The study is led by a team at NORC and supported by the NSF rapid response research (RAPID) program. They released a report last month that is cause for further concern about the challenges facing emerging scholars and America's research capacity.

Institutional leaders reported 67 percent of their STEM research was delayed or discontinued. Less than one-quarter (24 percent) of institutions reported that graduate students received consistent advising from graduate faculty during COVID-19, and even fewer (12 percent) said that virtual advising was an adequate replacement for in-person

contact. About two-thirds (67 percent) of institutions reported they anticipated needing to cut the budget of their graduate school programs as a result of the pandemic and its consequences.

These additional data only underscore the need to act on the kinds of recommendations outlined in our Focus Group report where federal investment could help to enhance institutional and organizational responses to COVID-19 that are essential, equitable, and forward looking. One such example is the NSF Career-Life Balance (CLB) Supplemental Funding Request (NSF 21-021) that is congruent with the needs and concerns expressed by many participants in our focus group.

AERA and our peer associations strongly support the Research Investment to Spark the Economy (RISE) Act and the Supporting Early-Career Researchers Act. The RISE Act would provide a much needed infusion of funding to address costs from disruptions to research grants; provide financial support and flexibility for faculty, postdoctoral researchers, and graduate students; and help cover expenses required for ramping research back up as labs and research facilities reopen. The Supporting Early-Career Researchers Act would help keep early career researchers whose employment opportunities have been affected by the pandemic in the STEM pipeline through a new National Science Foundation fellowship program. Both of these bills would help mitigate the loss of research talent and ensure the long-term viability of American research. This moment presents an important opportunity to not only protect and bolster American's research capacity during and after COVID-19, but also make sure that the historic inequities within the sciences are not exacerbated as women and persons of color face the worse of the pandemic's effects.

Interpersonally, organizationally, or systemically, institutions, leaders, senior scholars, and policymakers at the federal, state, and local levels are at a pivotal time to support the next generation of researchers and thereby the very research enterprise that relies on them. The risks to their futures and to the country that benefits from their insights and innovation are far too great to lose this opportunity. We ask your committee to lead, to act in our nation's best interest, and to do so with one voice and without hesitation.

Felice J. Levine
Biographical Sketch

Felice J. Levine is Executive Director of the American Educational Research Association (AERA). Her work focuses on research and science policy issues, research ethics and conduct, data access and sharing, the scientific and academic workforce, and diversity and inclusion in higher education. She is principal investigator of the longstanding AERA-NSF Grants Program. She is principal investigator of an NSF-funded collaborative project to build a data hub to connect data resources, foster new scholarly networks, and advance research capacity in STEM education. She is also collaborating on an initiative examining the impact of and fostering academic support for open science products. Most timely, Levine is engaged in a multi-method study of the impact of COVID-19 on early-career education researchers and doctoral students.

Levine chairs the Board of the Council of Professional Associations on Federal Statistics, co-chairs the Societies Consortium on Sexual Harassment in STEMM, and is a member-at-large of the Social, Political, and Economic Sciences Section of the American Association for the Advancement of Science (AAAS). Levine also serves on the Board of the Consortium of Social Science Associations and the Board of Databrary as well as on the Advisory Group of the Center for Engineering, Ethics, and Society and the Advisory Group of the Humanities Indicators Project. She is a Fellow of the American Association for the Advancement of Science, the American Educational Research Association, and the Association for Psychological Science and an elected member of the International Statistical Institute. She holds A.B., A.M., and Ph.D. degrees in sociology and psychology from the University of Chicago.

Chairwoman JOHNSON. Thank you very much. Your testimony was very complete. Mr. Thomas Quaadman.

TESTIMONY OF MR. THOMAS QUAADMAN,
EXECUTIVE VICE PRESIDENT,
CENTER FOR CAPITAL MARKETS COMPETITIVENESS,
U.S. CHAMBER OF COMMERCE

Mr. QUAADMAN. Good morning, Chair Johnson, Ranking Member Lucas, and Members of the Science, Space, and Technology Committee. Thank you for your bipartisan leadership on key research and development initiatives and for the opportunity to discuss the role R&D is playing in fighting the COVID–19 virus and how R&D can help the American economy keep its leading edge in an increasingly competitive international marketplace.

R&D is a wide-ranging process that advances the strategic interests of the United States, improves the health and well-being of all Americans, and gives our consumers access to high-quality products that allows them to enjoy the highest standard of living in a global economy.

As you know, there are three areas of research: Basic research, which is theoretical in nature; applied research, which is directed at a specific aim; and development, which is used to create new products or improve existing products.

The American R&D infrastructure revolves around three pillars made up of the Federal Government, academia, and the private sector. Generally, the Federal Government, often working through academia, tends to focus on basic research, the business community leads on development, and all three play significant roles in applied research.

Intellectual property (IP) rights provide a basis for collaboration and technology transfer among all three. This infrastructure thrives as a result of long-standing and strong bipartisan support from Congress, including funding and the passage of key bills last year. Other long-standing laws such as the *Bayh-Dole Act* and the *Leahy-Smith America Invents Act* make the U.S. intellectual property system the most reliable in the world. These bipartisan initiatives have made the United States the global leader in R&D since the start of World War II.

While we know many past accomplishments, America's R&D leadership has been on full display in the effort to combat COVID–19. Pfizer and Moderna developed and deployed highly effective vaccines in less than a year, and Johnson & Johnson will soon follow suit. The Pfizer and Moderna vaccines are based on new technology called mRNA that allows a person's RNA to be programmed to produce vaccines. This treatment can be revolutionary in treating other diseases such as cancers and chronic conditions that impact millions of Americans. MRNA was based upon decades of academic and private sector R&D. Artificial intelligence shaved off months if not years of research to narrow the scope for researchers to target other drugs that can be used to treat and prevent COVID–19. This took an all-nation approach. There have been over 1,100 clinical trials in all 50 States covering over 410 congressional districts.

While we must still defeat the pandemic, the tools are coming online to do so. This would not have been possible without the long-term R&D efforts by life sciences companies or the short-term laser-focus bipartisanship in the Federal Government, academia, and the private sector.

Despite these successes, America's global R&D leadership is in peril. Currently, 70 percent of spending in the United States is performed by the private sector. In the mid–1960's 70 percent was undertaken by the Federal Government. Federal Government R&D spending has fallen to 2.8 percent of the budget, its lowest point in 60 years, and has gone down consistently since the 2008 financial crisis. China has been closing the gap rapidly. Since 2000, U.S. R&D spending has grown by 4.3 percent annually while Chinese spending has grown by 17 percent annually.

A key factor of future competitiveness is R&D intensity or the share of R&D spending to the economy. Currently the United States ranks 10th. We believe there are concrete bipartisan steps that can reverse these negative trends and maintain America's leadership in research and development. This can be done by enacting and passing the *RISE Act* to mitigate the impact of COVID–19 on our national research enterprise and lay the foundation for future discoveries and innovation, ensure that recently enacted R&D legislation including the *National Artificial Intelligence Initiative Act*, *CHIPS for America Act*, and the *Energy Act of 2020* are fully implemented and funded. Increase funding for the Technology Modernization Fund and other programs in order to digitally transform government. Modernizing government platforms will enable greater real-time collaboration and strengthen the Federal Government's research capacity. Identify additional opportunities to reverse the decline in Federal investments in R&D with a focus on basic research, maintain the ability of private companies to immediately deduct R&D expenses, enable the private sector R&D investment to a recommitment to the patent system. These steps will be critical for the United States to remain a leader in areas such as semiconductors while establishing a commanding position in areas such as artificial intelligence and quantum computing. In doing so, we can recover from the impacts of the pandemic and lay the foundation for the United States to lead the industries of tomorrow. I'm happy to take any questions you may have.

[The prepared statement of Mr. Quaadman follows:]

BEFORE THE U.S. HOUSE OF REPRESENTATIVES COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
Hearing on "Building Back the U.S. Research Enterprise: COVID Impacts and Recovery"
Testimony of Tom Quaadman, Executive Vice President, U.S. Chamber of Commerce

February 25, 2021

Good morning, Chairwoman Bernice Johnson, Ranking Member Lucas, and distinguished members of the House Science, Space, and Technology Committee. My name is Tom Quaadman and I am the Executive Vice President at the U.S. Chamber of Commerce's[1] Center for Capital Markets Competitiveness (CCMC), Chamber Technology Engagement Center (C_TEC), and the Global Innovation Policy Center (GIPC).

Now in its second year, the COVID-19 pandemic represents one of the greatest challenges to the United States in the 21st century, leading to more than 500,000 fatalities in the U.S., affecting nearly every facet of our everyday lives, and crippling millions of small businesses.

Innovation is the key to enabling the United States to emerge from the pandemic, spurring economic recovery, creating jobs, and continuing America's global leadership. The private sector is leading, and in many cases, is collaborating with academia and the public sector such as on advanced pharmaceuticals like the COVID-19 vaccines. Technologies such as artificial intelligence are helping solve many of the problems we are facing today, like accelerating drug discoveries and enabling our understanding of the virus. Broadband and the Internet are keeping the digital lights on for businesses, enabling children to learn in virtual classrooms, and enabling us get medical care through telehealth. At the same time, Congress will need to undertake an urgent effort to modernize government information technology infrastructure to help us solve problems like vaccine distribution in real-time, advance leadership in key emerging technologies, and bridge the digital divide. Fundamental to these critical and society-sustaining technologies is a healthy and robust research and development ("R&D") ecosystem.

However, America's national research enterprise, a world-class network of federal agencies, colleges and universities, and industry labs, has not remained untouched by the pandemic. This issue will need to be addressed by policymakers as we continue to grapple with the numerous challenges associated with COVID-19. In addition to this issue, this testimony examines industry's overall role in facilitating R&D, key challenges and opportunities, reasons to prioritize investments in R&D, importance of tax policy and intellectual property protections, and policy

[1] The U.S. Chamber of Commerce is the world's largest business federation, representing the interests of more than 3 million businesses of all sizes, sectors, and regions, as well as state and local chambers and industry associations. The Chamber is dedicated to promoting, protecting, and defending America's free enterprise system.

recommendations for Congress to bolster our national research enterprise, and sustain America's leadership in R&D. Congressional leadership in this area that has been most effective and stood the test of time, such as the Bayh-Dole Act and the Leahy-Smith America Invents Act, have been bipartisan efforts and we hope this Congress continues that tradition.

I. IMPACT OF COVID-19 ON THE NATIONAL RESEARCH ENTERPRISE

Last September, this Committee's Research and Technology Subcommittee held a hearing on the adverse impact of COVID-19 on university research, finding that the pandemic has affected universities' ability to conduct research through reduced physical access to university laboratories, caused pauses to on-going research, and led to staff reductions, among other significant impacts.[2] Moreover, much of academia has implemented hiring freezes and consequently, science, technology, engineering, and mathematics ("STEM") faculty job openings have decreased by 70% compared to 2019.[3] Over the long term, and without a course correction, the impacts of CODID-19 on academic research will have negative ramifications on America's economic competitiveness.

Members of Congress, such as Representatives Diana DeGette and Fred Upton, have appropriately recognized the threat COVID-19 poses to our national research enterprise through the introduction of the Research Investment to Spark the Economy ("RISE") Act, which would provide support to America's research enterprise.[4] This bipartisan solution would allocate $25 billion across several federal agencies to supplement research grants and contracts, sustain core research facilities that have been shuttered by the pandemic, and mitigate the impact on graduate students and other early-career researchers through additional opportunities. The U.S. Chamber supports the RISE Act's goals and urges the Committee and Congress to advance this bipartisan legislation and other initiatives to protect our national research enterprise and sustain America's long-term economic competitiveness.

II. LONG-TERM CHALLENGES TO U.S. GLOBAL COMPETITIVENESS

While the nation continues to grapple with the effects of COVID-19, policymakers must take the long-view and look ahead to the wide range of challenges and opportunities the country will face over the next few decades.

The national research enterprise is a crucial building block of America's global economic competitiveness and national security. Fortunately, due to our world-class universities and

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[2] The impact of the COVID-19 crisis on university research. Hearings before the Subcommittee on Research and Technology, of the House Committee on Science, Space, and Technology. 116th Cong. (2020). https://science.house.gov/hearings/the-impact-of-the-covid-19-crisis-on-university-research (accessed February 18, 2021).

[3] Katie Langin. Amid pandemic, U.S. faculty job openings plummet. Sciencemag.org, American Association for the Advancement of Science. October 6, 2020. https://www.sciencemag.org/careers/2020/10/amid-pandemic-us-faculty-job-openings-plummet#:~:text=Faculty%20job%20openings%20at%20U.S.%20institutions%20are%20down%20by%2070,dates%20with%20no%20new%20postings (accessed February 18, 2021).

[4] RISE Act, H.R. 7308, 116th Cong. §2 (2020). https://www.congress.gov/bill/116th-congress/house-bill/7308 (accessed February 18, 2021).

innovative private sector, America's research capabilities remain the envy of the world and exceed that of the nation's economic competitors. However, U.S. leadership is no longer assured. China, the European Union and others are intently focused on dislodging the United States from its unquestioned leadership position at the commanding heights of global innovation. China, in particular, is rapidly investing in research and development, endeavoring to build self-sufficiency in foundational technologies, and achieve absolute dominance in emerging technologies and industries of the future. According to the American Association for the Advancement of Science, the annual growth in R&D expenditures, public and private since 1995, in the United States rests at roughly 3.5%. However, China's growth rate exceeds 15% and has reached $463 billion in 2018.[5] It is imperative that policymakers come together on a bipartisan basis to address these immense challenges.

III. OVERVIEW OF U.S. RESEARCH AND DEVELOPMENT ACTIVITIES

Since the end of World War II, the United States has been a global leader in conducting R&D, consisting of roughly 69% of the total spent globally in the immediate post-war period, involving significant collaboration and investments from the public and private sectors.[6] Today, while the United States spends $580 billion annually, our global share of R&D spending has fallen to 27.7% reflecting significant progress made by other countries to compete with the United States.[7] Stakeholders, including industry, academia, and the federal government, all play important roles across the spectrum of R&D activities and all need to be successful for the America's research enterprise to continue the lead the world in innovation.

R&D encompasses a number of different activities, including basic research, applied research, and development. In the aggregate, these activities lead to the private sector commercialization of new products and processes and the creation of new industries and American jobs. Basic research, also called fundamental research, includes experimental and theoretical research to garner a stronger understanding of natural phenomenon, and develop scientific theories. Applied research seeks to address particular problems and utilize that research for specific products and processes. Finally, development utilizes research gained from basic and applied search to create or improve new products and processes.[8]

For example, the Defense Advanced Research Projects Agency ("DARPA") collaborated with academia and the National Science Foundation to develop the protocols and initial infrastructure that laid the basic foundation for the modern-day internet. The private sector though has been

[5] Matt Hourihan. A snapshot of U.S. R&D competitiveness: 2020 update. R&D Budget and Policy Program, American Association for the Advancement of Science. (2020): https://www.aaas.org/sites/default/files/2020-10/AAAS%20International%20Snapshot.pdf (accessed February 18, 2021).
[6] Congressional Research Service. (2020, January 24). *U.S. research and development funding and performance: fact sheet,* CRS Report No. R44307 (1). https://crsreports.congress.gov/product/pdf/R/R44307 (accessed February 18, 2021).
[7] Ibid, 2-3.
[8] Ibid, 3.

responsible for connecting the vast majority of Americans online and technology companies have brought e-commerce, virtual learning, and telehealth into the mainstream.

The COVID-19 Vaccine: A Case Study in the Intersection of Basic Research and Private Sector Innovation

The development of a COVID-19 vaccine provides an instructive example of how basic research ultimately feeds in the creation of new and innovative commercial products and how government, academia, and the private sector can collaborate to address critical challenges.

The Pfizer and Moderna COVD-19 vaccines both utilize a fairly novel technology called synthetic messenger RNA or mRNA. Researchers at University of Pennsylvania, Katalin Kariko and Drew Weissman, spent over a decade conducting research on synthetic mRNA and published the findings in 2005. This foundational research inspired founders of Moderna to use mRNA for medicines and raised $2 billion on the concept before going public in 2018. Soon after the world became aware of the COVID-19 virus, Moderna researchers used the mRNA technique to create a vaccine and was one of the first drugmakers to develop a vaccine suitable for clinical trials. Operation Warp Speed, through funding appropriated by the CARES Act, provided Moderna with $2.58 billion in two grants to facilitate development of their vaccine.

Likewise, Pfizer and its German partner BioNTech also utilized mRNA to develop a COVID-19 vaccine. BioNTech similarly licensed the novel technology developed at the University of Pennsylvania to try to harness the medical potential of mRNA. At the onset of the pandemic, BioNTech partnered with Pfizer, an 171 year old biopharmaceutical company, to develop and test their mRNA vaccine candidate. While Pfizer did not receive R&D funding through Operation Warp Speed, the federal government agreed to pay $1.95 billion to purchase 100 million doses of the vaccine.

Federal support for basic research is not the only public policy whose benefits are highlighted by the new vaccines. Immigrant innovators were often the tip of the spear, and the ability of firms to draw on global production networks sourcing inputs from around the globe has proven essential to the development and deployment—with unprecedented speed—of these novel and impressive vaccines. There are important lessons here for elected officials considering the direction of U.S. immigration, trade, and supply chain policies.

Last December, the Food and Drug Administration granted emergency use authorizations for both the Pfizer-BioNTech and Moderna mRNA-based vaccines. The story of both vaccines illustrates how basic federal funding – for either R&D or the medicines themselves – paired with private sector expertise can lead to game-changing medical innovations in record time.

i. Stakeholder Contributions to the National Research Enterprise

Academia, industry, and the federal government are all essential components of America's research enterprise and uniquely contribute to the nation's collective R&D activities. In 2018,

academic institutions contributed $20.4 billion of R&D activity, 62% of which went to basic research and 25% of which went to applied research.[9] The Federal government invested $127.2 billion in R&D, 42% of which went to basic research and 34% towards applied research.[10]

Industry constitutes the largest share of all types of R&D funding in the United States, specifically ***69.7% or $404.2 billion annually***. Although it is unsurprising that industry produces the vast majority, or 85.2%, of all development research considering the crucial role the private sector plays in developing new products and services, industry also makes substantial contributions to basic research (29%) and applied research (54.3%).[11]

Finally, the Federal government, the private sector, and academia frequently collaborate on R&D initiatives though shared resources and funding opportunities. For example, the federal government and industry contributes, 41.9% and 4.7% respectively, to academic institutions for R&D expenditures.[12] Overall, 55% of all federal R&D expenditures is performed by either academia or industry underscoring the importance of stakeholder partnerships. Policymakers should continue prioritize these stakeholder partnerships and ensure that academia, industry, and the federal government has a seat at the table in determining how to strengthen America's research enterprise.

ii. Decline of Federally-Funded Basic Research

While academia, the federal government, and industry continues to make significant investments in R&D, a concerning trend line exists, which will put America's global competitiveness at risk if not sufficiently addressed. Federal R&D expenditures as a percentage of the federal budget currently rests at 2.8%, a 60-year low.[13] The share of private sector expenditures of R&D expenditures has increased from 32.3% in 1965 to 69.7% today.[14] The decline in federal R&D investment has negatively impacted basic research, considering that the federal government, and by extension, academia, is primarily responsible for conducting that type of research. Given the foundational role basic research plays in facilitating applied and development research, and subsequently new and improved products and services, the current trend will likely limit industry's future capability to innovate and commercialize innovations stemming from scientific advancements. In turn, this will put the United States at a global disadvantage compared to other countries, such as China, which is increasingly prioritizing funding for R&D. To address this

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[9]Josh Trapani and Michael Gibbons. Academic Research and Development. National Science Board, Science and Engineering Indicators 2020, National Science Foundation, Report NSB-2020-2. https://ncses.nsf.gov/pubs/nsb20202/academic-r-d-in-the-united-states (accessed February 18, 2021).
[10]Congressional Research Service. (2020, January 24). *U.S. research and development funding and performance: fact sheet,* CRS Report No. R44307 (3). https://crsreports.congress.gov/product/pdf/R/R44307 (accessed February 18, 2021).
[11]Ibid, 3.
[12]Josh Trapani and Michael Gibbons. Academic Research and Development. National Science Board, Science and Engineering Indicators 2020, National Science Foundation, Report NSB-2020-2. https://ncses.nsf.gov/pubs/nsb20202/academic-r-d-in-the-united-states (accessed February 18, 2021).
[13]James Pethokoukis. "U.S. federal research spending is at a 60-year low. Should we be concerned?" The American Enterprise Institute (blog), May 11, 2020. https://www.aei.org/economics/us-federal-research-spending-is-at-a-60-year-low-should-we-be-concerned/ (accessed February 18, 2021).
[14]Ibid.

risk, the Chamber believes that Congress, on a bipartisan basis, should seek to reverse this trend and prioritize federal investments in R&D, especially in basic research.

IV. IMPORTANT PURPOSES AND APPLICATIONS OF RESEARCH & DEVELOPMENT

As has been discussed, R&D investments are necessary to enable the development and ultimate commercialization of innovative products and services. Federal research in the 1950s, for example, led to the development of GPS by the U.S. Department of Defense. Today, GPS is utilized across a number of economic industries including the aviation and automotive sectors, and has led to creation of new business models and products such as on-demand ridesharing and smartphones. However, investments in R&D also yield a number of additional benefits outside of novel commercial applications important to the long-term success of the United States.

i. Addressing the COVID-19 Pandemic

Investments in R&D are helping to address critical challenges facing the nations and the world such as COVID-19. In addition to the contributions of R&D to the development of mRNA-based COVID-19 vaccines, public-private partnerships such as the COVID-19 HPC Consortium leverage the supercomputing resources of industry and federal laboratories to combat COVID-19 with research through supporting dozens research projects including accelerating drug discovery, identify appropriate therapies for COVID-19 patients, and understand the virus.[15]

ii. Driving Climate and Energy Innovation

Addressing climate change is a priority for the business community and one where federal support plays a crucial role. Governments at all levels and businesses of all sizes are committed to taking on the challenge of climate change, and in recent years have announced a growing number of ambitious energy transition goals. The development and commercialization of new low-carbon technologies will be the primary factor that determines whether these goals can ultimately be achieved.

That is where the federal government's role is essential, and why the Chamber worked closely with this Committee last Congress as it played a major role in passage of the Energy Act of 2020. Arguably the most important climate and energy legislation to pass Congress in over a decade, this law expands federal efforts in a broad suite of technology areas, including energy storage, advanced nuclear, and carbon, capture, utilization, and storage to industrial technologies and grid modernization research.[16]

The Energy Act of 2020 is exactly the "kitchen sink" approach to climate technology solutions the nation needs, and it passed in bipartisan fashion, proving that there is common ground on which all sides of the debate can come together to address climate change. More importantly, however, it also presents a major long-term growth opportunity for U.S. businesses. With the

[15]COVID-19 HPC Consortium, https://covid19-hpc-consortium.org/ (accessed February 18, 2021).
[16] Energy Act of 2020, Section-by-Section. Senate Committee on Energy and Natural Resources. 116th Congress. (2020). https://www.energy.senate.gov/services/files/32B4E9F4-F13A-44F6-A0CA-E10B3392D47A (accessed February 18, 2020).

federal government providing the foundation, we can restore American leadership in clean energy innovation and take advantage of immense opportunities to export climate change solutions to the rest of the world.

iii. Strengthening National Security

A strong research enterprise is essential to strengthen our national security, both through federally-funded and private sector investments. In Fiscal Year 2020, the U.S. Department of Defense constitutes a significant share of federal R&D funding, 44.3% of all federal R&D spending.[17] Critically, much of these activities are carried out by industry and academia, highlighting the importance of public-private R&D collaboration to sustain national security.

5G security has emerged as crucial example of how investments in R&D can strengthen national security through securing our telecommunications networks. Section 501 in the Fiscal Year 2021 National Defense Authorization Act (S. 4029) established the Public Wireless Supply Chain Innovation ("R&D") Fund and the Multilateral Telecommunications Security ("MTS") Fund.[18] These programs will promote U.S. leadership, competitiveness, and supply chain security in 5G, a critical backbone for future economic growth. The R&D Fund would provide grants to companies to develop and deploy Open RAN technologies, while the MTS Fund would support the global development and deployment of secure and trusted telecommunications in consultation with America's foreign partners.[19]

iv. Ensuring American Leadership in Industries of the Future

Industries of the future, including artificial intelligence ("AI"), quantum information science, semiconductors, and advanced communications technologies like 5G will be long-term drivers of global innovation. United States leadership in these technologies is essential to maintaining global competitiveness and national security, and continued prioritization of industries of the future for R&D will be key achieving that objective.

Congress, primarily through the work of this Committee, has demonstrated significant bipartisan leadership in charting a path forward for these important technologies. Last year, the Fiscal Year 2021 National Defense Authorization Act ("NDAA"), included the bipartisan CHIPS for America Act to boost federal investments in semiconductors.[20] The CHIPS for America Act will help reverse the decline in semiconductor manufacturing in the United States. Semiconductors are essential in a host of cutting-edge technology fields and essential to U.S. economic and national security; currently 9 out 10 top public companies by market cap are dependent on a strong semiconductor sector. Also, the impact of the ongoing semiconductor shortage on the automotive sector has demonstrated how critical other industry sectors are on semiconductors

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[17]Congressional Research Service. (2020, March 18). *Federal research and development funding: FY2020,* CRS Report No. R45715 (4) https://fas.org/sgp/crs/misc/R45715.pdf (accessed February 18, 2021).
[18]National Defense Authorization Act for Fiscal Year 2021, H.R. 6395, 116th Cong. TITLE XCII, §9202 (2020). https://www.congress.gov/bill/116th-congress/house-bill/6395/text (accessed February 18, 2021).
[19]U.S. Chamber of Commerce (2020, August 19). NTIA comments on national strategy to secure 5G. https://www.uschamber.com/comment/ntia-comments-national-strategy-secure-5g (accessed February 18, 2021).
[20] National Defense Authorization Act for Fiscal Year 2021, H.R. 6395, 116th Cong. TITLE XCIX (2020). https://www.congress.gov/bill/116th-congress/house-bill/6395/text (accessed February 18, 2021).

and how federal support and investment is crucial to strengthening the resilience of semiconductor supply chains.[21]

The NDAA also included the National Artificial Intelligence Initiative Act, comprehensive bipartisan legislation to establish a multi-billion national R&D initiative for AI, centered around programs at the National Science Foundation, the Department of Commerce, and the Department of Energy. The legislation also created a task force to investigate the feasibility of creating a national AI research cloud, which will enable academia, industry, and the federal government to share computing resources, reduce the cost of compute for researchers, and facilitate collaboration on key AI challenges.[22] This legislation is critical to ensuring U.S. global leadership in AI and providing a strong foundation to address the risks and opportunities posed by this technology.

v. Supporting Standards Development and Rules of the Road

Industry-led, voluntary consensus standards are a bedrock in establishing a common baseline of understanding that can inform regulatory actions and ensuring U.S. leadership internationally on standards and rules of the road. The federal government, primarily through the Department of Commerce's National Institute of Standards and Technology ("NIST") contributes to the development of standards through providing technical expertise, but also conducts research activities to establish the technical foundation for standards. In addition, NIST plays an important coordination role in convening relevant stakeholders and identifying gaps in research necessary to develop a particular standard. Ultimately, NIST's work is important to the free enterprise system considering industry relies on standards to reduce the cost of product development, expedite market entry, and open new markets at home and abroad. Moreover, the United States benefits when industry and the federal government effectively influences the development or revision of international technology standards.

For example in the AI space, the National Artificial Intelligence Initiative Act tasked NIST to lead the process in establishing a voluntary and stakeholder-driven risk management framework for AI, a concept based on the NIST's Cybersecurity Framework. The AI risk management framework will establish common definitions for key terms pertaining to AI trustworthiness such as bias, explainability, and ethics, as well as providing and identifying relevant standards and other processes to develop, assess, and mitigate risks regarding trustworthy AI.[23] Cross-disciplinary research conducted by academic, federal government, and industry stakeholders will help inform the development of the framework. Ultimately, the framework will serve as an important tool to ensuring that all stakeholders are part of the discussion to determine how to appropriately manage risks stemming from AI while guaranteeing the United States remains at the forefront of innovation.

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[21]Marcus Williams. Semiconductor shortage will hit auto industry well into 2021. Automotive Logistics. January 19, 2021. https://www.automotivelogistics.media/news/semiconductor-shortage-will-hit-auto-industry-well-into-2021/41476.article (Accessed February 18, 2021).

[22]National Defense Authorization Act for Fiscal Year 2021, H.R. 6395, 116th Cong. Division E, TITLE LI, §5106 (2020). https://www.congress.gov/bill/116th-congress/house-bill/6395/text (accessed February 18, 2021).

[23] National Defense Authorization Act for Fiscal Year 2021, H.R. 6395, 116th Cong. Division E, TITLE LIII, §5301 (2020). https://www.congress.gov/bill/116th-congress/house-bill/6395/text (accessed February 18, 2021).

V. THE NEED TO REPEAL A HARMFUL R&D TAX CHANGE

Beginning in 2022, businesses in the United States will no longer be able to immediately deduct their R&D expenses and will instead be required to deduct or amortize these expenses over several years. This policy would make the United States a global outlier on how R&D is treated.[24] It is imperative that Congress act to maintain the ability to immediately deduct these expenses, thereby encouraging continued investment and innovation within our borders.

Private sector R&D investments in the United States drive economic and job growth. Further, for every $1 billion in private sector R&D spending, 17,000 jobs are supported in the United States.[25] These R&D-related jobs pay an average annual wage of nearly $135,000.[26] We must maintain immediate deductibility for R&D expenses to ensure the United States can remain a leader in innovation and the job and economic growth that comes with R&D investments.[27]

VI. ROLE OF INTELLECTUAL PROPERTY RIGHTS TO INNOVATIVE R&D

The strength of the U.S. patent system is a key driver of private sector investment in R&D and a fundamental underpinning for America's competitive advantage in innovation. The private sector relies on the legal certainty of U.S. intellectual property (IP) rights to make long-term, high-risk, capital-intensive investments in innovation (e.g., in the bio-pharmaceutical sector nine of ten prospective medicines entering clinical trials will fail and the one that succeeds may take a decade of development and testing at a cost of billions of dollars before ever reaching a patient).

In a ranking of countries accounting for more than 90 percent of global GDP, the U.S. Chamber International IP Index[28] (the "Index") has consistently scored the United States as the leading IP system in the world, measured by strength of rights, predictability, reliability and access to due process. Moreover, analysis of Index data[29] has demonstrated highly positive correlations between a country's IP strength and its performance against indicators such as innovative and creative output, access to innovation and creativity, and job creation in knowledge-intensive industries, among a number of other socio-economic goals.

This advantage has contributed to make the United States uniquely successful in translating both public and private investments in basic research into usable end-products, a process referred to as commercialization. According to the Small Business Administration, "Early stage small businesses face difficult challenges accessing capital, *particularly those without the necessary*

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[24] Ernst & Young. Impact of the amortization of certain R&D expenditures on R&D spending in the United States. (ii). October, 2019. https://investinamericasfuture.org/wp-content/uploads/2019/10/EY-RD-Coalition-TCJA-R-and-D-amortization-report-Oct-2019-1.pdf (Accessed February 18, 2021).
[25] Ibid, 12.
[26] Ibid, 10.
[27] For additional background, discussion, fact sheets, and relevant data, please visit the R&D Coalition website, available at https://investinamericasfuture.org/.
[28] U.S. Chamber International IP Index, Eighth Edition. February 2020. www.uschamber.com/ipindex (accessed February 18, 2021).
[29] https://www.theglobalipcenter.com/wp-content/uploads/2019/02/023593_GIPC_IP_Index_2019_Annex.pdf; Statistical Analysis of the U.S. Chamber International IP Index. February 2019.

assets or cash flow for traditional bank funding."[30] (emphasis added) For innovative start-ups and small businesses—who face a particularly acute challenge due to the inherent technical risks of commercializing unproven technologies—intellectual property rights are the indispensable assets necessary for access to capital.

Licensing of IP rights, which in turns depends on their predictability and reliability, further sustains an ecosystem for innovation by providing a basis for financing, collaboration, and technology transfer among diverse partners, from government, to universities, to start-ups, to larger companies with the ability to test and manufacture at scale. Patents, in essence, form the currency which allows for exchanges of value within this innovation ecosystem.

By allowing the assignment of intellectual property rights derived from federally-funded grants to be licensed to the academic and private sector researchers who make the relevant discoveries, the **1980 Bayh-Dole Act** became a critical element of U.S. R&D success in recent decades. Bayh-Dole established a fair, appropriate, and pragmatic system for the federal government to transfer proprietary rights in research. It has been critical to the success of the United States in bridging the "valley of death" and ensuring that scientific knowledge translates into usable products, services, and technologies that both serve end-users and advance national strategic priorities.

VII. POLICY RECOMMENDATIONS

The COVID-19 pandemic has demonstrated glaring vulnerabilities in our national research enterprise, which if not addressed, will pose a long-term risk to U.S. competitiveness. Moreover, the decline in federally-funded basic research and increased geopolitical competition from China and others underscores the necessity for Congress on a bipartisan basis to take the lead in bolstering our R&D capabilities.

The Chamber recommends that Congress take the following actions to support our national research enterprise during the pandemic and leverage R&D to support the long-term competitiveness of United States:

- Enact the RISE Act to mitigate the impact of COVID-19 on our national research enterprise and lay the foundation for future discoveries and innovations.

- Ensure that recently-enacted R&D legislation, including the National Artificial Intelligence Initiative Act, CHIPS for America Act, and the Energy Act of 2020, are fully funded.

- Increase funding for the Technology Modernization Fund and other programs in order to digitally transform government. Modernizing government platforms will enable greater real-time collaboration between government and the private sector and strengthen the federal government's research capacity.

[30] https://www.sba.gov/offices/headquarters/ooi/resources/34981 (accessed February 18, 2021)

- Identify additional opportunities to establish new programs or strengthen existing programs to reverse the decline in federal investments in R&D, with a particular focus on basic research.

- Maintain the ability to immediately deduct R&D expenses.

- Enable private sector R&D investment through a recommitment to the predictability and reliability of the U.S. patent system.

VIII. CONCLUSION

The Chamber appreciates the opportunity to discuss COVID-19's impact on our national research enterprise and on how research and development activities strengthens American competitiveness. America's business community looks forward to continuing to work with the Committee and its members on solutions to address the adverse impact of COVID-19 and other crucial policies to unleash American innovation.

Tom Quaadman

Executive Vice President, U.S. Chamber Center for Capital Markets Competitiveness, Senior Advisor to the Senior Executive Vice President

Thomas Quaadman is executive vice president of the U.S. Chamber Center for Capital Markets Competitiveness (CCMC), the Chamber Technology Engagement Center (C_TEC), and the Global Innovation Policy Center (GIPC).

CCMC was established in March 2007 to advocate legal and regulatory policies for the U.S. capital markets to advance the protection of investors, promote capital formation, and ensure U.S. leadership in the financial markets in the 21st century. Quaadman oversees the Center's policy and lobbying operations. He also works with CCMC staff to create and execute legislative, regulatory, and judicial strategies to reform the financial regulatory system and support policies for efficient capital markets.

C_TEC was established to tell the story of technology's role in our economy and advocate for rational policy solutions that drive economic growth, spur innovation, and create jobs through the backing of a leading national and global business organization.

And GIPC works around the world to champion innovation and creativity through intellectual property standards that create jobs, save lives, advance global economic and cultural prosperity, and generate breakthrough solutions to global challenges.

Quaadman headed the Chamber's efforts on the Dodd-Frank Wall Street Reform and Consumer Protection Act and the Jumpstart Our Business Start-Ups Act (JOBS Act). In addition, he formed and managed several coalitions, including the Corporate Governance Coalition for Investor Value and the FIRCA coalition on the convergence of domestic and international accounting rules. In directing the Chamber's work on corporate governance, Quaadman led successful

efforts to overturn the SEC's proxy access rules and have a portion of the Conflict Minerals Rule declared unconstitutional.

He has testified on a number of occasions before congressional committees on issues covering capital formation, financial reporting, and corporate governance. He also led the business outreach efforts for the Working Group on U.S. RMB Clearing and Trading. In 2012, *Treasury & Risk* magazine named Quaadman as one of the top 100 influential people in finance. Quaadman graduated cum laude from New York Law School and is a graduate of the College of Staten Island. He is a member of the New York and Connecticut state bars. Quaadman and his wife, Tara, and their children, Creighton and Alexandra, reside in Alexandria, Virginia.

Chairwoman JOHNSON. Thank you very much. We've had fantastic testimony. And let me just say that many of the questions that I've had you have touched on. We know this, we'll now begin our questioning, and I'll yield myself 5 minutes.

The COVID–19 crisis has affected research across the board, but some disciplines have been harder hit than others. Experimental researchers have had limited access to their laboratory equipment and have experienced a larger disruption of their work than researchers working on theoretical science and computing. Perhaps more importantly, the STEM pipeline has been harmed by this crisis. Graduate student training and mentoring has suffered from limited access to library space, laboratory space, collaborators, and field sites. We are seeing elevated rates of anxiety and depression among graduate students, particularly among marginalized groups. Undergraduates aren't getting the hands-on research experience that inspired them to pursue STEM as a career, and universities are instituting hiring freezes to save money, which has resulted in a 70 percent drop in the faculty job market.

As a result, some early career researchers are facing the difficult decision to leave research in order to support their families. Women researchers have taken on the majority of the additional childcare responsibilities that have arisen due to the pandemic, and this has resulted in slower research progress for women compared with their male counterparts, which threatens to widen the gender gap in STEM faculty representation, reversing years of incremental progress.

A recent Council on Government Relations model estimated that research output dropped by 20 to 40 percent since March of 2020. The study estimates that the financial impact is tens of billions of dollars across the research enterprise.

What I would like you to help us focus on is while the *CARES Act* provided some funding for science agencies, it fell well short of the need and was focused specifically on COVID research. And likewise, the funding being considered as part of the current reconciliation package is focused on COVID-related research. The bill text should be published probably very soon, but the *RISE Act* will help, I think, tremendously.

But what I'd like each of you to point out, we've got all the problems on the table and all the concerns. Please give us some direct recommendations that we can utilize and make sure that we don't deteriorate this enterprise anymore. I can start wherever you'd like. Dr.—yes. Is Dr. Levine still——

Dr. LEVINE. Yes, I'm here. I can——

Chairwoman JOHNSON. OK.

Dr. LEVINE. I can start first. Yes, I can. You know, I think you have [inaudible] joined the research community in your command of exactly what we seek for supporting the research enterprise from high-energy physics to education research from field sites and studies to experimental studies in the social and behavioral sciences. And the money and the support for flexible funding is really imperative. Not only do we need to widen the net of those who can receive particularly early career flexible kinds of grants, for example, those that were part of the National Science Foundation Career-Life Balance (CLB) supplemental funding offered ways of

supplementing for the kinds of things that researchers have lost. They may need childcare support. They indeed may need some additional counseling. They may need bandwidth to do some of the social networking worldwide that has been limited.

The one thing I would say as a concrete recommendation while I praise CLB, it is a supplement. Now, were this kind of initiative also to be able to be an early career funding mechanism, you would really be able to widen the scope of scientists across fields of science. Every field of science has taken a hit. And that has also affected building capacity in scientific fields. If I can say for one moment, the deep commitment of this Committee for science education and capacity building at the K–12 level, at the undergraduate level. We need to ensure the talent pool is there to be able to do that teaching across levels of education. They are doing it multi-fold in the past year since the onset of COVID–19.

But we hear reports that for those who are teaching, for example, in universities and colleges in more rural locations where the bandwidth may be for their students, that the students ride and sit in a car with the children in the backseat, and they are trying to do online learning. So this has wide-ranging opportunities for this Committee to grapple with in a way that not only advances the enterprise of science but also the next generation of scientists. And that's why I mentioned science literacy. You need to have those skills to develop a modern workforce.

Dr. KEANE. Yes, Chairwoman Johnson, if I could add into that, this is Chris Keane, thank you for your great summary of the situation, by the way. It was very helpful. Just a couple things.

Again, I support the *RISE Act*, but in thinking about financial relief, I think it's important to bear in mind there are sort of three issues. First, there's direct—relieving direct costs of the pandemic, which tend to squeeze budgets for hiring and everything else.

Secondly, there's the 20 to 40 percent you mentioned, which really has to do with the cost of delay for existing projects and displacement of our researchers. Just getting that work done and making up for that loss of productivity in the short term is vital so we don't lose much of our workforce as a result of this crisis.

And then the third component of relief is basically the longer-term investment in the R&D enterprise. Again, I would just point out as a stat that, you know, the $25 billion proposed in the *RISE Act* is less than half the gain that China is making on our [inaudible] expenditure figure every year. And so when you add up those three areas, direct relief from the pandemic, you know, addressing the 20–40 percent impact on our researchers, as well as the long-term issue of enhancing research expenditures and funding generally, it's a big request. We really appreciate your help on this.

And just one other point I'd mention we haven't covered yet, the—with respect to diversity and inclusion needing the full benefit of our talents in the United States, that's vital. One thing we need is more data to support that actually, and I believe the *STEM Opportunity Act* if I recall correctly calls for collecting that data, so I'd urge you, via that act or some other means, to increase the amount of data that we collect on diversity, inclusion, and equity so we can better assess our situation. Thank you.

Mr. QUAADMAN. Chair Johnson, if I could just quickly add as well, you know, we fully support the *RISE Act*, which is important to address human capital issues, also fully agree as well in terms of the need to help increase Federal research dollars, particularly around basic research.

Additionally, we also think it is very important that we also engage in things like IT (information technology) modernization within the government, which is one of the things the pandemic has shown is how we have a great need for IT modernization.

And just lastly, the bipartisan leadership that you and Congressman Lucas and this Committee have shown last year in the passage of the artificial intelligence legislation, as well as the *America Energy Act*, and other legislation, those need to be fully funded and implemented for us to start to deal with some of the longer-range issues as well.

Chairwoman JOHNSON. Well, thank you very much. My time has really expired. I've enjoyed your input and want more, but I've got to now ask Mr. Lucas if he'll do his 5 minutes of questioning.

Mr. LUCAS. Thank you, Madam Chair. As we've heard today, Mr. Quaadman, the impacts of the COVID pandemic will be particularly detrimental to basic research. And given the fundamental role basic research plays in facilitating applied and developmental research and subsequently new and improved products and services it creates, the losses will likely limit industries' future capacity to innovate and commercialize innovation stemming from scientific advances. Can you discuss how this threat is impacting industry and may impact the United States' future economic competitiveness?

Mr. QUAADMAN. Yes. Thank you, Ranking Member Lucas. This is all to do with America's long-standing competitiveness. We have both China and the European Union, which are greatly increasing their research funding as a means to dislodge American global leadership. While our competitors have also faced some of the constraints because of COVID–19, we really need to address some of the issues in terms of funding. We also need to address other ancillary issues such as the ability to [inaudible] R&D expensing by the private sector so that we can continue to grow the private-sector role in this as well.

But I would just raise one last point as well. The country that leads in innovation is the country that also sets the rules and builds the products that are based upon that innovation. That is the traditional role the United States has played, and that is not a role that we would want to cede to other countries that may not share the same values that we do in terms of coming up with those rules.

Mr. LUCAS. Continuing with you, Mr. Quaadman, on February 2nd the Executive Vice President of the Chamber of Commerce, Neil Bradley sent a letter to President Biden and Members of Congress. And in this letter he warned against the use of reconciliation to pass the American Rescue Plan and stated, "Such an approach will certainly make it more difficult to reach bipartisan agreement on other policy priorities." Can you elaborate on why the majority's budget reconciliation process has been so detrimental in any

progress toward bipartisan solutions for American families, businesses, and communities?

Mr. QUAADMAN. Yes, thank you for that question, Ranking Member Lucas. First off, the four COVID relief bills that have passed before this legislation were bipartisan in nature. We believe that, you know, with the Democratic view of relief being broad-based and for Republican views that it be more targeted and temporary, that a synthesis of those views will lead to better legislation.

Additionally, we don't think that the political well should be poisoned where we have to deal with other important pieces of legislation that are going to have to be bipartisan in nature such as infrastructure.

The last point I would say with the reconciliation process, what the reconciliation process does is it creates the dollar figure, and then the policy needs to follow that dollar figure. We would rather see that we come up with what the right policies are and then determine what the dollar figure is after that.

Mr. LUCAS. Dr. Keane, in essentially my last question, in your written testimony you highlighted the important role land-grant institutions have played in working in close collaboration with local, State, and national public health authorities officials to ramp up COVID testing. And I will acknowledge I'm especially excited to hear about the great work Oklahoma State University did in developing testing capacity for both its campus and the State of Oklahoma. Can you please discuss the mission of land-grant institutions and how it becomes even more important when facing this pandemic or pandemics of this type in the future?

Dr. KEANE. Thank you, Ranking Member Lucas, for that very nice question. Yes, I completely agree with you that the mission of our land grants is just—its importance has been highlighted by this pandemic. As you know, that mission is threefold: teaching, research, and service. And never have they been more important. And in fact on the teaching side our faculty and staff have risen to that challenge despite rising enrollments and getting used to the virtual world, extra [inaudible]. They have risen to the challenge and continue to educate our students.

In the research world we've heard about, as you discussed, the things we've done in testing as a service that's provided to our local communities, and that's been very important. For example, here in Washington State the WSU, our testing facility is looking at the community in terms of supporting the spread of disease and the community understanding that, but also we're directly testing wastewater from our elementary schools, which supports the ability of our schools to open in fact. So there's a direct community benefit there.

And finally, in service, the third part of our mission through extension, that's a huge part of what we do here in Washington State, at Oklahoma State, and many other land grants. We have a presence in every county where we aid our citizens every day and numerous other programs in that area.

So all in all, the pandemic has just highlighted this critical mission of service, research, and teaching at the land grants in numerous ways. The APLU has a particular report on this subject. There's more information and numerous specific examples on their

website [inaudible] and our other land-grant institutions, so thank you for the opportunity to express the importance of these institutions.

Mr. LUCAS. And probably it's underappreciated how important President Lincoln's signature on the *Morrill Act* in——

Dr. KEANE. Yes.

Mr. LUCAS. —1862 and the ability for non-wealthy Americans, average Americans scattered around to begin the availability of a public education. Thank you, Doctor. I yield back, Madam Chair.

STAFF. Ms. Stevens is next.

Ms. STEVENS. Great, thank you. This has been a very thorough hearing so far, and the testimonies have been absolutely tremendous.

I represent Michigan, and we've seen this at Oakland University with 59 percent of Oakland University's research labs being operational, 25 percent face-to-face, and the impacts at the university level. Tom, in particular, I appreciated your testimony where you touched on the collective R&D efforts coming from the Federal Government, the Federal Government corporations, as well as from universities. And we know we're continuing [inaudible], right? We funded the NSF, you know, as a government and appropriated it, and we certainly also appreciate the Chamber's support of the American rescue package and the triage work that we need to do to continue to save lives and bring our economy back. Thank you for your partnership there.

Dr. Parikh, I would love to talk with you. You have a—just a fabulous background, and we so appreciate your leadership of AAAS. You know, we love the publication. I get it every week. Your testimony was quite thorough. One of the things I'd love to drill down on with you is regarding what we're actually talking about here, which is our basic R&D spend, right, in terms of what's being lost with the applications. Have you at all taken a look at the TRL, the technology readiness levels, particularly as we're in that, you know, early stage of technology readiness and that as we move forward to application? Because we do the basic R&D, and we know we're losing it. You know, we love your formula. You know, if we've got a formula down on the percentage, but have you at all taken a look at the technology readiness levels at all in terms of the impacts of COVID–19?

Dr. PARIKH. We haven't specifically, but we have a team that can do that kind of analysis. I'd be happy to come back to you with that. What we have—when you think about it, it's—in its simplest form, it's a conveyor belt, right? And so as this thing—as we have things that are moving from basic research, through development, through applied, through product, when we have this disruption that is COVID–19, it's the same thing with people. What ends up happening is you get a logjam in that conveyor belt. Yes, we have the funding for next year. You might ask, well, why can't we just use the funding from next year to continue this work? You can except there are students that are piling up behind the students that are currently here. There are products piling up, there are technologies piling up, and we've got to make sure that we're unclogging that conveyor belt.

Ms. STEVENS. Yes, we want to take a look at that because as we move into the application phase—and where I am in the world of this is, you know, intensive automotive, right, what's taking place with the proliferation of electric vehicles, autonomous vehicles. We're obviously also [inaudible] with the supply chain disruptions and what we've seen taking place with this chip shortage. Now, I've got a bill on that, the *Resilient Supply Chain Task Force Act*, which helps us monitor the ongoing health of our supply chains.

But the next phase of what we're looking at here is production, and we have got to be making in America. We know this, but you don't just get to say let's make it in America, right? You have to do the basic R&D.

Dr. PARIKH. Absolutely.

Ms. STEVENS. Then you got to look at your technology readiness. So I'd really love for you to follow up with me on that.

And I'm going to be generous to my colleagues because I love them and there's a great group here on both sides of the aisle that's here today. And I got about a minute left, but we got a lot of people online, so I'm going to cede the rest of my time, Madam Chair, and I will also say Chairwoman Johnson is spot on with having this hearing right now, and thank you. I yield back.

Chairwoman JOHNSON. Thank you very much. Next?

STAFF. Mr. Perlmutter is next.

Chairwoman JOHNSON. OK.

Mr. PERLMUTTER. Don't we want a Republican to go before me?

STAFF. I'm sorry, sir. Mr. Brooks is next.

UNIDENTIFIED SPEAKER. And I may be next as well?

STAFF. Mr. Posey is next.

Mr. POSEY. Thank you, Chairwoman Johnson and Ranking Member Lucas, for holding this hearing. It's important to ensure that American science and technology research remains the best in the world.

This pandemic has dramatically disrupted life for Americans, and we need to do whatever we can to return things to normal.

My question is for all of the witnesses. You know, as mentioned, there's been significant disruptions in our STEM and research pipelines to our universities by COVID–19 pandemic, but perhaps the most concerning disruption has occurred far earlier in this vital pipeline. Just last week in our last hearing we heard about some of the effects of school closure on our students. My colleagues and I drafted a letter to our wonderful Chairwoman requesting a hearing on the concerns that too many of our K–12 schools remain closed when science says that they can reopen safely. Even before COVID–19 universities were concerned that U.S. students were not prepared for the rigor of STEM education that are necessary to advance America's research and development projects in schools as opposed to others where schools are already reopened, as in China. What will happen when an entire generation of American students are further behind than their international peers? You know, will our U.S. colleges and universities simply fill the STEM slots with more foreign students? I think it's around 36 percent right now. Should K–12 schools be reopened or should we just accept the damages to the U.S. STEM research pipeline as part of the pandemic's

cost? And you can respond I guess in the same order that you gave your opening testimonies with Dr. Parikh first.

Dr. PARIKH. Thank you, Mr. Posey. K–12 education is so critical to the science and engineering enterprise. We have to have a broad pipeline at the beginning because every signal that is sent to a young student accumulates over time. And so when a young person is told, you know, maybe science is not for you, maybe you're better at the arts or you're better at something else, that really hurts us every time that happens to a young girl, every time it happens to a young man, every time it happens to somebody who has grown up on a farm or every time it's happened to somebody who's grown up in an inner-city. And so we've got to make sure that we're sending the right signals.

On opening schools, it's a complex question. I will leave that to my public-health counterparts as opposed to me, a biochemist, but what I would say is that all the things that can be done to get us to the place where we can—vaccination, doing the right public-health interventions like wearing masks, maintaining social distance, doing all those things will get us there faster than not doing those interventions. I think it's critically important to do that.

But education, we have got to make sure we're investing in that K–12 group beyond just the pandemic. We've got to get them doing science, and we've got to get kids doing science that are not our usual suspects because if we do that, we're never going to compete on sheer numbers with China. We've got to have all of our kids working toward STEM education and STEM fields.

Mr. POSEY. Dr. Keane?

Dr. KEANE. Yes, I—this is Chris Keane. Thank you for that question. As—you know, land-grant universities, as part of our service mission, as I mentioned earlier, do a lot of activities to support our K–12 education. Our extension programs provide programs for K–12 students, and also we take opportunities just to invite K–12 students in to see the exciting things that we do in research and education, get them excited about going to college——

Mr. POSEY. I don't want to cut you short, but we're short on time. Just kind of like your response to the questions I asked if possible.

Dr. KEANE. OK. I'll—yes, I'll stop there then. Sorry about that. I would just point out that, you know, our—like I said earlier our testing activity directly supports return to school. Thank you.

Mr. POSEY. Thank you very much.

Dr. LEVINE. Well, thank you for the opportunity of being able to speak to K–12 education. I just want to underscore with what Dr. Parikh opened with that we want to use—and indeed the great investment of work on COVID–19 at the Institute of Education Sciences in the Department of Education, Education and Human Resources Directorate at the National Science Foundation—that COVID work. In addition to the work at the CDC (Centers for Disease Control and Prevention) and the health sciences this research also gives us wisdom and understanding about how to implement a return to school in safe and secure ways that include the collection of data so that we know what happens in real time, the possibility being discussed, so, for example, a PULSE survey around education, around absenteeism that would continue to implement measures of testing and to take the wisdom also of educators,

teachers, counselors, and the school system about what can work in what ways.

And we clearly need to go back to innovating. And this is an opportunity for both research and education to innovate in such a way that we can—that we can bring our children back into a school environment to interact with their peers, to be able to not only engage in science, which is extraordinarily important, but in the other ways in which in the K–12 system children are learning about ways of working together, collaborating together, so important for the STEM workforce, and we need to recognize that there were tremendous inequities [inaudible].

And how we do this, the kind of queuing that I must say my colleague the biochemist spoke wonderfully about expectancy of things and implicit bias so that in my generation the most accomplished of my peers was a woman who wanted to go to medical school but it was implicitly and explicitly discouraged as "not for women," and she ended up going to law school and being a great lawyer and having a wonderful career. That kind of expectancy effect and sadly implicit bias continues in particular for persons of color and for women.

Mr. QUAADMAN. Mr. Posey, I'll be very quick. I know your time is expired, but, you know, the letter that Chambers sent to Congress this week on the American Rescue Plan included a section in there regarding school reopening, which we support. We made a suggestion of money being set aside solely for covering the expenses of those school reopenings and dealing with COVID cleanups and protecting children from COVID, but that the opening decisions need to be left to the States and the local districts.

STAFF. Thank you. And Mr. Perlmutter is next.

Mr. PERLMUTTER. Thank you. And just a couple questions because we do have a lot of people in the queue. I represent the suburbs of Denver, and we have a lot of laboratories, national labs, Energy, NOAA (National Oceanic and Atmospheric Administration), NIST (National Institute of Standards and Technology), USGS (United States Geological Survey) in the area. And as an example—and I'd like to get kind of an answer from all of you—the retooling costs associated with sort of reducing, you know, the number of researchers in a lab, so, for instance, the National Renewable Energy Lab has some 2,500 employees and contractors, and when they had to shut down more or less in March, April, and May of last year, they went from, say, 2,500 down to 100 and then have been gradually returning the workforce.

So I know as part of this package we're trying to make up for some of those lost costs. Have any of you thought about the retooling cost to get our labs back and operating at 100 percent? And maybe, Mr. Quaadman, you want to kind of take a cut at that first and then I'll go to the other panelists?

Mr. QUAADMAN. Sure, thank you very much, Mr. Perlmutter, and that's—that is an excellent question. And we view this that there are probably going to have to be multiple things that are going to have to be done. Clearly, the *RISE Act*, which we support and I think everybody here supports, is an important part of particularly protecting that human capital talent and making sure we're getting that back up and running, but you also make an excellent point in

terms of the technology in the labs. We believe that there's more that is going to have to be done there. Additionally, putting more of an emphasis around basic research and applied research is going to be an important part of that.

So we believe dealing with some of these short-term problems can actually help us pivot to also address some of the long-term problems, so we think this focus that this hearing is having today is an important start of that process.

Mr. PERLMUTTER. Thank you. Dr. Parikh, do you have any thoughts on that?

Dr. PARIKH. I do, thank you, Mr. Perlmutter. Well, first of all, the research going on at NREL (National Renewable Energy Laboratory) is so important to the Nation. You know, going down to 100 people for a time in March means that when there's an experiment going—there are—every type of experiment—every type of experiment has—that is a long-term experiment has constant check-ins by people. As much as the technology is powerful, it requires people checking things in. And because we had to shut down so quickly, planning was tough, right, so if we had tissue culture that was ongoing, we would take that down and we would—instead of having many, many petri dishes full of tissue culture, we would take it down to one and freeze it and save it for when we come back. But then when you come back, you got to grow it back out again before you can do any research at all. And that takes time, it takes people, and it takes reagents, it takes the lab space, and so it takes funding, it takes resources. And so as Dr. Quaadman said, the investment that we make here at this sort of inflection point is going to pay short-term dividends and long-term dividends.

Mr. PERLMUTTER. Thank you. I'd like to change the subject just a little bit for Dr. Levine and Dr. Keane in terms of the students. So in the front range of Colorado we have the School of Mines and University of Colorado. CSU (Colorado State University) has a big infectious disease lab that has been operating. In terms of the talent pool and this pipeline of young scholars, again—and you've answered this already, but just specifically what has sort of this delay of a year done to that pipeline? And I'd start with you, Dr. Levine.

Dr. LEVINE. Well, I think the delay of a year has had several adverse impacts. One, even the workforce, the talent in labs, structured labs or even the broader laboratories of field research doing intervention studies, while there's been a tremendous amount of really exciting work ongoing, as Dr. Parikh underscored earlier, innovation and collaboration to try to do things in a very different way, there is that loss of not working hand-in-hand, not being able to bring in, not having the support to bring in the postdocs, the layered way in which science occurs.

The laboratory is an environment where the undergraduate—I started my research career as an undergraduate working with doctoral students, working with postdocs and with faculty. That kind of exchange does not happen and has not happened in the same way, and it's going to take an investment. It's also going to take an investment in things like REUs, research experiences for undergraduates, and that kind of investment can make a difference. But I think the consequence is substantial.

Mr. PERLMUTTER. Thank you, Doctor. And Dr. Keane, I'm sorry, my time is expired. Somebody else will get to you.

STAFF. Thank you. Mr. Sessions is next.

Mr. SESSIONS. Thank you very much. And I want to thank each of our panelists for being here today. Certainly, Dr. Keane, Dr. Parikh, Dr. Levine, thank you. Thomas, thank you, I think it's Quaadman, we appreciate you being here.

The question that I have focuses on giving people money while we're still closed, and I'd like for you to address that in your own way because I think this money should be given when people open, not when people stay closed. Anyone of you, please.

Mr. QUAADMAN. Well, Mr. Sessions, I—you know, I guess I could take an early crack at that. Look, we believe—this is one of the reasons why I gave the answer that I did to Ranking Member Lucas is that we think that there should—there needs to be a discussion of, you know, the broad range of potential policy initiatives that we need to address the COVID vaccine. So part of the reason why we do need broad-based relief is to deal with small businesses that are teetering on the brink of closure, some permanently——

Mr. SESSIONS. I'm sorry. I'm sorry, I made a mistake, Tom. As it relates to the *RISE* bill.

Mr. QUAADMAN. Sure. So I was just going to get there. And with the *RISE Act* what we need to do is to make sure that we are keeping the human capital in place, that we can have that human capital move forward as we open up those labs so that we can flip that switch and get things up and running because, unfortunately, what has happened over the last year is because there's some work that can be done, right, in terms of research paper or the like, but there's other type of experimentation which cannot be done, and we need to get up and running as quickly as possible not only to keep pace with our competitors but actually to get up and running before they can.

Mr. SESSIONS. Yes, well, I understand competition, but I also heard our panelists say it's up to States and local people, universities. For instance, I represent a small university, Texas A&M down in College Station, that is one of the leading, I believe, research and development universities in the world. But my point is if they make a decision to stay closed, let's say, until January of next year, that means that they have students that are dropping out, that means students that are going somewhere else. The question is do we fund them before they open?

Dr. PARIKH. Mr. Sessions, if I may, the students we're talking about funding here are the graduate students in the sciences and engineering and, you know, they are—they're working right now. They are writing research papers. They are doing what they can with labs at half capacity and that sort of thing. The challenge becomes this conveyor belt that I've been talking about. So you have these students are working right now and we've got to keep them—they're in this holding pattern. And then we got students coming up right behind them. And if we lose those students because they say, you know what, I don't—science and engineering is hard enough anyway. I'm not going to make a whole lot of money when I first graduate, maybe I should go be a lawyer, I should go into something else, when that depletion of that human capital that Dr.

Quaadman was talking about is so critical to us right now because every other nation on earth is investing in that human capital. If we bleed that human capital in the short term, the money appropriated a year from now won't do the same thing as the money appropriated today.

Mr. SESSIONS. OK. I do understand this, but we're kind of dancing around this. Look, I spent a number of years at Bell Labs in New Jersey. My son just finished medical school a couple years ago. I get graduate medical education (GME). I do get these are the brightest and best. Why do we want to delay anything or make it more difficult? That's not my point. Should a university or a program receive money before they open?

Dr. KEANE. So, Representative Sessions, thank you for that question. This is Chris Keane. Just—I know time is short, just a quick example. So, as you've heard, we have continued a lot of operations virtually, but take a laboratory just as a very simple example. A laboratory had to close because of COVID. On the other hand, some of the students and faculty could go home and write papers and write grant proposals and do other work that they, you know, normally wouldn't have the time to do if they were in the lab, so these folks do a lot of critical work, and so they can do [inaudible] of work at home.

Mr. SESSIONS. OK. Let the record reflect that we're not sure about whether—I know people are doing work. I did work during this, too. I think we ought to consider that the inducement for going back to work, because that's a question, you get the money when you produce that, and that means you make a series of decisions about your workforce including making sure they all have the COVID vaccine. We've heard testimony in this Committee how the vaccine works, and just a week or two ago we heard that the vaccine is the No. 1 thing you can do. And then you have a safe workplace, a whole lot of other things. I'm just saying in my mind going back I don't mind funding that, but I do have problems with not finding a way to get back to work, which is what we were paying for. So I appreciate the opportunity for each of you. I would expect you to be advocates, as I am, for the sciences, for GME, graduate medical education, graduate education, and all of the mathematic and physics programs. But I think we ought to put a caveat in there when you go back to work.

Thank you very much. I yield back my time, Madam Chairman.

STAFF. Mr. McNerney is next.

Mr. MCNERNEY. Am I recognized?

STAFF. Yes, sir.

Mr. MCNERNEY. Thank you. Well, I want to thank the Chairwoman for holding this hearing and the Ranking Member, very good, and also the panelists. I appreciate your work here.

Dr. Keane, in your testimony you state that in order to comply with Federal grant financial timeframes, many projects are having to close out without meeting their stated goals. What is needed to help grant awardees get the time and resources needed to make up for the COVID-related setbacks?

Dr. KEANE. Thanks for that question, Representative McNerney. I think—it's a great question. I think the comments you've heard from the Committee and elsewhere about the 20 to 40 percent,

which was developed by a number of our APLU members, that's sort of—that's an estimate, you know, of the loss of work due to delay. I think one can make some estimates of what the financing is to recover that, I think that basically is a short summary of what's needed.

Mr. MCNERNEY. Well, thank you. Well, Dr. Keane, in normal times before the pandemic, the life of a science researcher may have been professionally rewarding but was financially challenging. And I speak from personal experience here. Graduate students must forgo well-paying jobs for about a decade while their peers move ahead financially. And meanwhile, the grad students have no assurance at all of landing a modest or secure job at the conclusion of their studies. And I know Dr. Parikh sort of talked about this, but how does the pandemic impact this dynamic?

Dr. KEANE. Yes, well, it's—yes. No, I was going to say, certainly, Representative McNerney, the pandemic has been difficult on graduate students, postdocs and others, and it's—we've lost some critical talent there. And so we've tried to adapt by doing various things virtually and things of that sort, but it is a significant issue.

Mr. MCNERNEY. Well, thank you. Mr. Quaadman, I'm interested in understanding what's worked in leveraging R&D to help us bring the virus under control. In your testimony you mentioned the COVID–19 High Performance Computing Consortium. How did that collaboration come about, what did it accomplish, and what lessons do you think could be applied to future crises?

Mr. QUAADMAN. Thank you very much, Mr. McNerney. And I appreciate the promotion but I'm not a doctor. I have a J.D. but not a doctorate.

But first, I would also like to thank your leadership and the leadership of Mr. Gonzalez of the Artificial Intelligence Caucus as well, which has been very critical.

I actually think the COVID–19 High Performance Computing Consortium is a very interesting development, right, where we had the private sector through Amazon, Google, IBM, Microsoft combining with National Science Foundation, Department of Energy, along with MIT (Massachusetts Institute of Technology), UT (University of Texas) Austin, and the University of Wisconsin where they created a sharing mechanism of computing power to help in terms of research regarding COVID–19.

Part of the challenge that we have with R&D is also to ensure that smaller actors and smaller businesses have some of that access to let's say computing power as an example in terms of their R&D. So if we can create similar sharing mechanisms—and frankly, the *National Artificial Intelligence Act* that was passed last year creates some frameworks like this—it actually allows us to have a much more comprehensive approach to R&D, and we hope that is replicated elsewhere.

Mr. MCNERNEY. Well, thank you. Well, last week, millions around the globe watched in high definition as NASA (National Aeronautics and Space Administration) successfully landed the Perseverance rover on Mars. Landing a rover on another planet is a huge accomplishment in any time but must be more difficult under a pandemic. Dr. Parikh, how have conditions under COVID

challenged this type of high-pressure mission-critical event for large, distributed research and engineering teams?

Dr. PARIKH. It's been incredibly challenging, and that's why it's even more compelling and more inspiring to watch the video from last week. The way it's happened is that people have had to work in the same that we are, right? They're working over Zoom, they're working over Webex in contrast to being in the same room, drawing on a piece of paper, and that makes it harder. But I can tell you that the inspiration that comes from watching these engineering teams double-check and triple-check their work because they are having to work this way, I think it also just highlights what a small team of diverse people can do in competition with gigantic teams around the world is just extraordinary to see that type of inspirational work. And the science that's going to come from it is amazing as well. But just the engineering feat of landing on Mars is—look, my kids—my 11-year-old, that's what gets him excited about science. They like biochemistry, but they love that.

Mr. MCNERNEY. Well, they don't want to go to Mars themselves. At any rate, I want to yield back and I thank again the Chairwoman for yielding to me.

STAFF. Mr. Webster is recognized.

Mr. WEBSTER. Thank you, Chair. I had a question to Dr. Parikh. So we're in competition not with just ourselves but with other countries, especially in the area of STEM and, you know, trying to make sure we're there, we're setting the pace, we're out front, all of that, and somebody was talking about losing potential STEM stars to a law degree or some other profession. Are we also losing to our competition? Are there countries that we're losing out or people are getting [inaudible] research dollars, something like that, and moving? Is that happening?

Dr. PARIKH. It is happening. So we see—just overall, you know, the NSF puts out the science and engineering indicators, and the U.S. global share of science and engineering publications has always been ahead of everybody else. Well, that is not true anymore. China has overtaken us. It's also been in terms of number of S&E degrees that are awarded. But they also have very, very targeted programs to recruit stars from Europe and from the United States and then to also keep talent within their borders.

And, look, there are challenges to that in terms of intellectual property and that sort of thing, but even if everything was fair, what it says is they've got—they've got a plan, and plan beats no plan almost every time, and so we have to have a plan. We have to be making sure that we are doing our absolute best to recruit the best talent from the United States whether it be from the farm belt, the sun belt, or the coast, and also the best talent from around the world. We have been the beneficiaries of a crossroads of talent here in the United States, and we cannot let that pass. We are still right there at the top, but we are in danger. We are in real danger of losing that position because all these successes that we've talked about, they're lagging indicators of previous investment and all the stuff that's gone on for the last 30 years. It's not a—it's not any guarantee of what's to come.

Mr. WEBSTER. Thank you, sir.

Dr. LEVINE. If I could amplify just on that, I really want to underscore that our leadership edge in science has been very well-served by the United States really being an international leader in the international community of science, so we lose our competitive edge when scientists and scholars and students from other parts of the world don't look to us as the educative environment to do what they do best. And whether they remain in the United States or they go to other locations, that significantly affects not only the knowledge we produce but the sense of centrality we are in the international community.

I'm not an economist by training, but my sense of some of the work on patents is that when a country has had the highest participation of the international community in our higher education system, that we have—that has enabled discoveries in our own country. And that's just one example of something I think we need to really be looking at and a point I earlier wanted to make but you've asked the right question at the right time.

Mr. WEBSTER. OK. Well, there's this conveyor belt that's jammed up all over the place and there's STEM students in high school and all the way to postdoctorate, all that, so shouldn't we put our money where the bleeding is and try to stop the bleeding if we're prioritizing? Is that a good statement to make?

Dr. PARIKH. I think that's absolutely a good statement. We should prioritize. We should prioritize. And I think human capital is right there at the top. Making sure that we have the supply chains fixed as well is right there after it and by supply chains I mean, in terms of bringing back the infrastructure, bringing back the technology, bringing it back online. But human capital is at the top of my list.

Mr. WEBSTER. All right. I yield back.

STAFF. Mr. Tonko is next.

Mr. TONKO. Thank you. And I thank you, Madam Chair, and our Ranker for today's hearing. It's so apropos that we be talking about the future here—through this lens. And to all of our witnesses, thank you.

Throughout the COVID–19 pandemic, we have seen and experienced for ourselves the impact this virus is having on work, on America's workers throughout our economy, and on workplaces across the country. For many, video meetings and conference calls had to quickly become the status quo. For others, much of their work simply cannot be done remotely.

The ability of scientists to advance their research remotely depends in large part, I believe, on the nature of their project and their discipline. For instance, research involving computations, data analyses and modeling and simulations lends itself more easily to work from home, but it is difficult if not impossible to conduct research requiring physical and biological samples and specialized equipment outside of a laboratory.

And so, Dr. Parikh, what areas of scientific inquiry have been most negatively impacted by COVID? And how are you seeing the researchers adapting to that?

Dr. PARIKH. Yes, thank you for the question, Mr. Tonko. You are absolutely right. You laid it out very well in terms of the challenges to field research, the challenges to clinical research, the challenges

to research that happens in a lab bench because, you know, if you've been in these laboratories you know that, especially in the successful ones, they're dense, right? We have graduate students and postdocs and scientists who are working together, and they're dense for a reason. We want them talking. We want them collaborating. We want them to run into each other on the way to the restroom and talk about math and physics and biology at the same time because that's where the excitement comes from. And so that—we are definitely hurting in the experimental sciences and in the clinical sciences.

And in the places where we have pivoted our critical sciences to COVID, it's an opportunity cost, right? We have work going on in Alzheimer's and work going on in cancer and work going on in sickle-cell anemia. That's got to keep going as well, and we've got to make sure that we're able to ensure that continues.

But I don't want to underestimate the impact also on things like physics. You know, being able to continue work on some of these amazing radio telescopes, you know, our ability to contact to the Voyager space probes was affected by this. We couldn't send 30 people to Australia to work on the antenna. We could only send five or six. And so there's a real cost across the sciences, but the experimental sciences are definitely where the biggest challenges are.

Mr. TONKO. Thank you. And, Dr. Parikh, again, for fields of inquiry that have been able to adapt more easily to working remotely, do you see any opportunities where this could spur greater collaboration and innovation?

Dr. PARIKH. Oh, my gosh, you know, we have seen—if there's been one upside to the pandemic, it has been that collaboration from peer to peer in the United States and around the world has just grown exponentially. You see young scientists talking to one another in the United States, in Europe, in China, in Japan. They're having conversations. And look, we need that because, again, COVID is not our last crisis, and we need to know that these scientists who are able to talk to each other right now, that's a relationship, and that relationship is going to continue for the next thing and the next thing and the next thing, and that is—that's incredibly important. We've got to keep up our part of it, though, as the United States and make sure we've got wonderful scientists here bringing everybody to us.

Mr. TONKO. Thank you. The COVID–19 crisis has resulted in many setbacks, and it will take our enduring commitment to help America's scientific research community recover. And to this end, last year, the Federal Government provided guidance, as well as administrative and salary flexibilities for universities and COVID relief legislation, including that which funded support research agencies. But based on your testimony—and I can confirm this based on my conversations with research institutions in my district in upstate New York—greater support is needed.

So, Dr. Keane, in your testimony you mentioned the administrative flexibilities that the Office of Management and Budget (OMB) provided to universities from March to September of last year. To what extent did these flexibilities from our Federal agencies, espe-

cially related to grant commitments, help mitigate the impact of the coronavirus pandemic?

Dr. KEANE. Thanks, Representative Tonko, for that question. Those flexibilities were very important to our faculty, students, and staff. They allowed things, for example, to, you know, to cover cost of PPE (personal protective equipment) and other unusual items. They allowed salaries to be paid. Under certain conditions [inaudible] working at home perhaps on different project than the contract. So it was essential to help transition through. And there's been a lot of interest as part of the recovery package trying to do something along those lines for—thank you.

Mr. TONKO. Well, thank you, Dr. Keane. And with that, my time has wound down, so I yield back, Madam Chair.

STAFF. Mr. Garcia is next. Mr. Garcia, you are muted. Mr. Garcia, you are muting and unmuting. I'm not sure if you're using a spacebar or if you're using——

Mr. GARCIA. There we go. Can we—can you hear me now?

STAFF. Yes.

STAFF. Yes, sir.

Mr. GARCIA. OK. All right, thank you. I apologize for that.

Dr. Parikh, I think you hit on something earlier that we all kind of glossed over, and that's the *RISE Act* deters the proliferation of lawyers, and I think we should rename it as such.

I want to focus in the realm of national security. We have roughly 44, 40 percent of our national R&D project is coming out of the national security realm, the labs, the DARPAs (Defense Advanced Research Projects Agencies) of the world. National security is relative, right, so as we either accelerate or decelerate relative to China and other threats, that's where threats will manifest, and that's where our weaknesses will become vulnerabilities. How are we able to compare how we're doing within classified realms, especially—but through our labs like DARPA and, relative to, say, the Communist Chinese military science research steering divisions? Do you have any insight how we're doing at the national security levels of both military and similar infrastructure investments? And I think, Dr. Keane, it sounds like you were touching on this earlier, but let's start with you.

Dr. KEANE. Yes, thank you. Thank you for that question, Representative Garcia. I think your question points out the vital importance of the research enterprise and the universities produce the young talent that goes to work in the national security enterprise. I have my own personal experience that's in the nuclear weapons program where there is just tremendous issues, you know, bringing in talent. As you probably know, the big labs right now, Livermore, Los Alamos, and so on are trying to hire 1,000 people a year to support the refurbishment of our stockpile, so this just speaks to the important mission that our universities and research ecosystems play in training these professionals to handle these national security challenges.

Mr. GARCIA. Yeah, but I think what I'm asking is how much insight do we have relative to China? Are they struggling in the same way that we are percentagewise? I think you mentioned that the rise of investments from the Federal Government on our side represents about half of what——

Dr. KEANE. Yes.

Mr. GARCIA. China is accelerating to our pace of over the last couple of years. That statement there, one, where is the data behind that statement, and how do we assess how much of an impact either COVID or the lack of investments writ large outside of COVID are having relative to the Chinese infrastructure investments?

Dr. KEANE. So I don't have any data relative to Chinese infrastructure, Representative Garcia, but the data I quoted is from the NSB (National Science Board) indicators 2020. If you look at that, you'll find a plot that basically shows R&D expenditures by country with China rising rapidly and the others, including the United States, relatively flat or only moderately rising.

Just a quick statistic, you know, from I believe it was 2000 to 2017 China's average annual rate of increase has been 17 percent in expenditures, and ours is 4, 4.5 percent. That pretty much summarizes it.

Mr. GARCIA. OK. And then so how do we ensure that these significant investments that we're making in the COVID packages are actually also gaining traction in the classified programs area, significant military development efforts that may not be enveloped in DOD (Department of Defense) programs of record quite yet? Some of these are at the university level, some of these are in labs. How do we ensure that these big dollars, these chunks of money being spent on COVID are actually still going through in support of our national security interests?

Dr. KEANE. Well, quickly, I'll say the university side, our primary connection was training workforce and so improving our infrastructure allows us to train better people in all fields, and people's careers change when they enter the national security word, so we do the fundamental training. I'll leave it to others to comment on the infrastructure in the national security world.

Dr. PARIKH. Mr. Garcia, I can speak a little bit to this. You know, the—there are two things at play here. One is the funding you're talking about in terms of how do we make sure that the national security research apparatus also sees some of this funding? I think that's very important. You're right. Approximately half, almost half of the—of our research dollars end up in some way going through national security.

My thought here is that we need to make sure that part of the scientific enterprise also sees these dollars because it's—that will also flow to the universities because they are the workhorses of that enterprise as well.

The other impact is on people, and if you look at China, you know, you were noting those dollars. The other thing to note is that they produce lots of scientists and engineers. And so when Dr. Keane talks about we need 1,000 hires a year at our national laboratories, it's easier when you're producing a lot more talent. And we're bringing that talent—we have to import some of that talent in addition to what's on the ground here, so we've got to do—it speaks again to that human capital aspect but also making sure that the full half of our enterprise that is defense-related needs to also see that funding.

Mr. GARCIA. Yes. Yes, OK.

Dr. LEVINE. If I could just add, one of the things that I think supports that infrastructure that we're talking about at the national security level is that if you look at the National Science Foundation indicators, locations like China have also invested substantially in building the talent pool to study the human resource issue, meaning the social and behavioral sciences have really grown in locations like China.

One of the areas internationally that is so central is work on the workforce. We've more or less disinvested in research on the workforce, and we support that activity, the investments in each of the Defense Departments and the social and behavioral sciences is not what it was 10 years ago, and there's often debates about really important activities like the Minerva Research Initiative that not national security research, but the knowledge base from that done in universities really has a tremendous value to our national security interests, I think that's part of the mosaic that you're asking about.

Mr. GARCIA. Yes, absolutely. OK. Thank you all. I yield back.

STAFF. Mr. Foster is next.

Mr. FOSTER. OK. Am I audible and visible here?

STAFF. Yes.

Mr. FOSTER. Well, thank you. And thank you to our Chairwoman, Ranking Member, and our witnesses.

I'd like to speak a little bit about Federal careers as potential jobs for early career researchers. Drs. Keane and Levine, you both highlighted in your testimonies that there were high levels of uncertainty in students and postgraduates with regard to future research opportunities due to COVID.

Now, pre-COVID, as my colleagues know, I was very active as a leader of the National Labs Caucus where I would drag my colleagues on visits to the national labs, including the national security labs. And during these visits, we would often arrange luncheons with young scientists and engineers who were getting things done, having a wonderful time, but there were simply not enough of them.

It was reasonably suggested by a professor friend of mine that there might right now be a real appetite amongst graduating STEM students, both graduate and undergraduate, to take STEM jobs in the government. Part of this is because of the Administration's renewed emphasis on science and scientific integrity and policy but also due to the genuine bipartisan support in this Committee and in Congress for ramping up Federal science funding over the next decade, which might make a career path in the Federal oversight of a growing science program more appealing than it may have been previously.

So, first, do you believe that this appetite exists? And if so, how do we capitalize on it?

Dr. LEVINE. I think that's a tremendously important question and I'm going to say opportunity. I should, I suppose, disclose that I myself went to the National Science Foundation as a visiting scientist for 3 years and stayed for 11. The opportunities with the scientific workforce within government, including actually in many State governmental agencies and institutions, is just enormous, and I think that having an understanding of those career ladders,

that you are not stepping out, you're stepping in, that these are significant science jobs where you can have very productive careers and that kind of synergism also between the academy and higher education and these laboratories needs to be amplified and supported, postdoc programs and other instruments that at this point in time, if the jobs are there, I think it's a great way of bringing some of the silos—you know, some of the silos together, and I [inaudible] raising it.

Mr. FOSTER. Yes. Well, do you think, for example, a virtual job fair highlighting the STEM jobs that are available across the many agencies of the Federal Government would be well-received right now?

Dr. LEVINE. Absolutely. Absolutely love it. And some of the agencies we work with at the American Educational Research Association—we're planning for our annual meeting, you know, those kinds of opportunities, whether they're visiting physicians or longer-term physicians, we're seeing a lot of handshake around that. And one of the things that's most important to understand is as the jobs have been delayed, denied, put on a back burner, including in higher education, the biggest concern of early career scientists is they don't know what jobs are real and what jobs are not real, so it's kind of incumbent upon us to collectively have this as a priority both in universities and [inaudible]——

Mr. FOSTER. On a sort of related issue, over the last four years, there's been a well-documented wave of early retirements of STEM professionals in government, you know, with a tremendous loss of accumulated experience and knowledge. Many of these were frankly driven by frustration over policies and proposed budget cuts, which we now are hopeful are going to be reversed. And so what do you think of standing up a program to call back some of these early retirees just for a couple years with the explicit goal of mentoring a next generation of younger and more diverse Federal STEM workforce?

Dr. LEVINE. I think it's a terrific idea. Every year as I get older and older, I underscore how terrific that is. I think that that—a loss of our sort of talent pool even in higher education institutions strapped for resources. And that's not to say those faculty leaders aren't remaining active as scientists, but having some kind of bring-back-mentoring kind of model I think is——

Mr. FOSTER. Yes. Yes, even if it's just a half-time job, my feeling is that a lot of people would be more than happy to pass their accumulated wisdom to the next generation, you know——

Dr. LEVINE. And let me say the National Academy of Sciences really capitalized on that kind of model in a noncrisis situation. Scientists from government may work in direct study panels and have various kinds of mixed models. I think you've hit—you know, you've pointed to something really important.

Mr. FOSTER. All right. Well, thank you, and it looks like my timer is down to zero. And I yield back.

STAFF. Ms. Kim is next.

Ms. KIM. Thank you, Chairwoman Johnson, and Ranking Member Lucas, for holding this important hearing. I am concerned that many of the lockdown and remote learning measures has worsened our students' low scores in math and science. Students in grades

K through 12 are the future of our STEM talent pipeline, and if they do poorly in subjects like math and science, our talent pool would eventually decrease, along with our competitiveness. As our Nation looks to recover from the COVID–19 pandemic, we should not forget our STEM students.

So I would like to pose a question to all witnesses. How has the COVID–19 crisis impacted our future domestic STEM workforce pipeline, and what are the implications of the potential loss of talent for the United States research and innovation ecosystem and economic competitiveness? Well?

Dr. LEVINE. One of us? I suppose we worry. I—you know, this is a—kind of a point that's been implicit, I think, of all four of our presentations, that we, you know, we worry about what that means in terms of everything from special services that will help deal with some of the socioemotional kinds of crises, and tensions, and ambiguities that early learners are experiencing as family members have died or lost their employment, and how—so that the development of the math, and science, and engineering talent pool needs to be understood in the ecosystem of—in which students and early learners live. We need to be considering what kind of programs that we offer wrapped around, and opportunities equitably and inclusively, around the school year having, or around that—the—this band of time off. What happens with after school programs? How do we invest in early education programs so that they are rich learning environments, and how do we both measure and accommodate learning loss?

STAFF. Miss——

Dr. LEVINE. That's a need for—that's a real need for data, also, that would be adjunctive to developing models of—I'll say models of accelerated compensation for loss this year.

Ms. KIM. Yeah, following up on that, Dr. Levine, over the last few years we have made some progress in increasing the number of women in STEM, and when I served in the California State Legislature, I had been one of the strong proponents of especially young girls coming to Sacramento, and in our capital, to also demonstrate the work that they're doing. So this is something that I have a great passion on. But how has the pandemic disproportionately impacted women in academic research, and what steps can this Committee take to address and tackle those roadblocks?

Dr. LEVINE. Well, I—the major way is the context in which students, graduate students, undergraduates, early career scientists, the context in which they live, and the disproportionate burden, particularly on women of color. Broad family responsibility. We'll see this in a number of preliminary—kind of top level findings from our survey, and also our focus groups, as disproportionate child care responsibilities, so that, at the end of the day, one is struggling with how to put the package together, and to, you know, keep the family all aware of what—one illustration was in one of the focus groups someone started the conversation by saying, I'm a faculty member, and I—I'm building upon the work I'm doing in kindergarten teaching, and I thought, I wonder whether she was a kindergarten teacher. And then she was talking about the fact that she was—she had a 5-year-old, and she was spending a big proportion of her day learning how to be a kindergarten teacher.

So that has consequences not only for her performance as a scientist, and her ability to engage at the level at which she is capable of performing, but it also affects, you know, let's put it this way, the role modeling of the fact that is cueing about the roles of women. Now, that's not to say that men with family responsibilities aren't also doing a very substantial share. It's just the data also show a—kind of a disproportionality where that stands.

Ms. KIM. Well, thank you. I yield back. I notice my time is up now. Thank you very much.

STAFF. Mr. Beyer is next.

Mr. BEYER. Thank you very much, and, Madam Chair, thanks so much for pulling this together, all of our witnesses. Very grateful, very fascinating.

Dr. Parikh, I have an intuitive question for you. We've heard through all the different testimonies about how detrimental and deleterious the COVID crisis has been for research, for the careers, or—et cetera, but we've also seen an historic commitment to biology and to genetics through the COVID crisis. Fastest ever vaccines to display—mRNA vaccines. How do you balance the 20-year leap forward in biological sciences against the downsides of the COVID pandemic on research?

Dr. PARIKH. It's an excellent question, Mr. Beyer. You know, the—if you had asked 2 years ago could we produce a vaccine from, you know, from sequence, to putting it into millions of people in a year, there wouldn't have been many people that said yes. There wouldn't have been many people at all that said yes. I would not have said yes. And so the progress that has been made and demonstrated by the biomedical research community is incredible, and it's inspiring to young people, right? There are people now—there are young kids who say, you know, I want to be, if not Dr. Fauci, then that other scientist. You know, but what I would say is, in doing that, we've raised expectations. We've raised expectations, and here's the problem, is that going into these fields is really tough. And so you've got young people who say, yes, I want to follow in Dr. Fauci's footsteps. Here's the problem, is that I run into this clogging the system that says, you know what, if you can't afford it when the pandemic happens, and you're a graduate student in Cambridge, and you don't have a family safety net to take you back in, then how are you going to continue your graduate studies on that, you know, that very small stipend?

So we've got this paradox—I mean, incredible inspiration, and yet the reality of the scientific career doesn't quite match up to that yet. And part of what—yeah, part of what this Committee can do is to help make those things align and match up.

Mr. BEYER. Let me interrupt you, only because we're limited to 5 minutes, but I'd love to have the other 30-minute conversation on this.

Mr. Quaadman, I come at this from a Ways and Means Member, with my pals Dan Kildee and Gwen Moore, and I'm concerned about, No. 1, the impact of *TCJA* (*Tax Cuts and Jobs Act*), that dropped the corporate tax rate from 35 to 21, 22, a quarter don't pay anything. I noticed in your statistics that corporations paid 400 billion in R&D last year, and I looked it up, and there was $525 billion in stock buyback, so 25 percent more in stock buybacks than

in research. Do you think moving back to having stock buybacks pre-authorized by the SEC (Securities and Exchange Commission) could move us in the right direction on research and development?

Mr. QUAADMAN. So, first off, I would say, as I said in my testimony as well, we do think it is important for that portion of the tax reform bill to be addressed so that we can continue the real time expensive R&D expenses. The only thing I would say in terms of stock buybacks, it's a little bit of an apples and oranges situation, because you have certain businesses that are not involved in R&D, that all they can do is actually give their money back to their investors. So I believe this is something that the SEC is going to probably be looking at after Gary Gensler is confirmed as chair, so we will have to see if—I think it's a little bit of an apples and oranges issue.

Mr. BEYER. By the way, Tom, I agree with you on the immediate expensing of R&D expenses, and that was just one of the things—it wasn't a policy decision. It was forced by the Byrd Rule in order to get TCJA through reconciliation, which I hope we can fix. But, Tom, a larger question—while listening—going through statistics, and our—your notion that our Federal R&D, the 2.8 percent's the lowest it's been in 60 years as a percentage of GDP, GDP increased from 2010 to 2020 by 22 percent, and our Federal R&D as a percentage of GDP was essentially flat. How do we make a national commitment to Federal R&D as a percentage of GDP so that we say it should be 4 percent, or it should be 5 percent, and make the long-term commitment to that?

Mr. QUAADMAN. Well, Mr. Beyer, I think that is an excellent question, and it actually goes to some of the points that Mr. Garcia was making as well about R&D with national security. Look, the Federal Government plays a very critical role in our R&D process infrastructure, and that basic research plays out in many, many different forms down the line. So I think, you know, if we take a look at the combination of the America—the *CHIPS for America Act*, the *National Artificial Intelligence Act* which passed last year, the *Energy Act* that passed last year, those can be used as a pivot point to start to increase Federal R&D, but as I referenced earlier as well, I think there are a number of other steps that we would like to talk to you about as to how we can increase that Federal research dollar, and see if there's some sort of mechanism to increase it over time, and also to ensure that we are keeping pace with our international competitors.

Mr. BEYER. Yeah. Thanks. My time's up, but thank you for the specific recommendations you gave us today.

STAFF. Mr. Feenstra, I think.

Mr. FEENSTRA. Thank you, Madam Chair, and Ranking Member Lucas. I first of all, I want to thank each of the witnesses for their testimony today. It is crucial for us to hear from each of you on how to best maintain the United States' role as leaders in science and innovation, and how we can help our Nation's research enterprises recover from the effects of the pandemic. I also want to say I really enjoyed the conversation concerning research and development tax credits. The State of Iowa is one of the leaders in research and development tax credits, and myself being chair of Ways and Means in the Iowa Senate over the years, I have seen

a tremendous value in what's happening with research and development tax credits, and how we have really driven research in our State, you know, when it comes to agriculture and biofuel.

But, with that, I have a couple of other questions. I'd like to center these questions to Dr. Parikh, and then to Dr. Levine, if possible. Representative Webster asked, and discussion was talked about, about losing high tech jobs overseas as students graduate, and we see this at our universities, Iowa, Iowa State. I was a professor at Dordt University, teaching business and economics, and we saw it there also. So the question is, Iowa State, we take STEM careers very seriously. Our Governor heads up a State advisory council to increase interest and achievement in STEM studies and careers. It works through partnerships that engage employers, nonprofits, students, and policyholders. So, as we talk about this, how should we increase STEM career interest after this pandemic? How do we get these kids to stay here, get them engaged? How do we get them involved? I know we've had some discussion about this, but I would like to hear more on your thoughts in this area.

Dr. PARIKH. Thank you, Mr. Feenstra, for the question. You know, one of the things is—something to come after the pandemic, is—people have gotten excited about this collaboration between government, and industry, and business in bringing therapies and vaccines to the people. Well, one of the challenges that we still have is this silo between academic scientists and industry scientists. There are a lot of industry—there are a lot of academic scientists, and our CVs, our résumés, don't look the same. And we don't know—it's very hard to cross those barriers. And I think everyone would gain if that student who's at Iowa State, and goes through the academic track, but then there's a fluidity where they can move into academic jobs or into industry jobs or into defense jobs, if that were easier, that would be a huge benefit to the country, and to business, and to the students themselves. So I think that's one way that we can do something after this pandemic is over that would make a huge difference for moving the science forward, and for people.

Dr. LEVINE. Let me just underscore, along similar lines, I think we need to look at our higher education system as part of the ecology of producing important work in science. So, for example, better networking of terrific faculty at—whether it's Grinnell, or other institutions that are primarily 4 year institutions, like—mentioned—of Iowa, that those faculty who are really igniting the interest of students in their undergraduate courses, that those faculty can place undergraduates in a summer program, in a lab, in a university, or in a national laboratory, or in an industrial setting, in a social behavioral sciences and a large survey research organization where they can touch and feel what happens on the ground.

I would not have myself pursued a science career if I was not invited as an undergraduate to work in a social psychology laboratory. That turned me from pursuing a different professional set of interests to the lab, and we need to be investing in higher education, including community college settings where there are exceptional faculty doing this work, to see this as part of the infrastructure. Not just the kind of synergism that I refer to, and Sudip just did, about the different kinds of silos, but also the siloing of institu-

tions, and thinking of teaching as not as meritorious and knowledge-producing as research.

Some of the stereotypic thinking of—as productivity, so that we encourage team science, which we all talk about as extraordinarily important, into disciplinary science shouldn't be viewed as left over after you achieve your credentials as a building block of your field. Team science as a disciplinary science produces extraordinary knowledge. We need to emphasize the—as we think about the science of the future. And I share the view that, actually—one of the most exciting—I lead this life in which I'm so excited by what we're inventing, and so overwhelmed by how to do it faster and better, so on the best days I'm just really excited about what the scientific community has been able to do.

Mr. FEENSTRA. Thank you so much for your comments. And I know my time is up, but I just quickly want to say this, is that I think we have to be innovative also when it comes to this private/public partnership. I know Tom, you mentioned this, on how we can do tax incentives with the colleges, the universities, and the private sector of saying, hey, what can we do to incentivize where these kids can go from the college role to the job role? And we've done this in research and development with a great tax credit. I just think there's ways to nuance this to even make it more successful. Thank you for your time, I yield back.

STAFF. Mr. Kildee is next.

Mr. KILDEE. Thank you. Can you hear me OK?

STAFF. Yes.

Mr. KILDEE. All right. Well, first of all, thank you to Chairwoman Johnson for holding this really important hearing. I do appreciate the testimony of the witnesses, and hearing ways that our researchers have been affected by the pandemic, and yet have still helped to combat, really in a pretty remarkable way, the spread of coronavirus. It is truly a remarkable achievement that we've seen just in the last year, particularly around—but obviously around vaccination.

Obviously our national research infrastructure is critical to all of us in so many ways. We have to ensure that it survives this moment that we're in right now, and that's why, like many, I'm just—in this hearing support the *RISE Act* to provide the relief necessary to—and to support federally funded research. Not only to provide emergency relief to support our researchers—public health crisis, but we also obviously have to sustain these research investments as we look forward toward economic recovery, and the long-term economic viability of the U.S.

Part of rebuilding our economy obviously includes investment in the infrastructure, but also specifically including energy infrastructure and clean energy technology. And I know Congresswoman Stevens, my in-state partner, mentioned this, but, you know, for example, putting more electric vehicles on the road, reducing carbon emissions, supporting investment in American-made manufacturing, this all protects our planet and helps us grow our economy.

So I wonder, Dr. Parikh, if you could perhaps address this question. If we don't invest in R&D in the technology of the future, like electric vehicles, other countries will, and I'm curious about what

your sense of that challenge really looks like for us. And then, if I have time, I would like to ask Mr. Quaadman also. Dr. Parikh?

Dr. PARIKH. Thank you, Mr. Kildee. You know, what's remarkable is over the last 75 years we developed this ecosystem, and we invested in it, and we did it pretty much alone, right? There weren't a lot of other nations that were doing this, and so we benefited greatly from it. And what's happened is everybody now understands the blueprint, and you all know this as Members of this Committee, that everybody now understands that blueprint. And we have to innovate beyond where they—where they're copying us. And if we don't, the scale of investment, that's coming, right? China can invest just as much as we can.

And so it's not about just the scale. We need the scale, but we also need the thoughtfulness of how do we incentivize industry, how do we incentivize industry and academia to work together, how do we do it in a targeted way, in a coordinated way?

We have over 20 agencies that do science research and development across the Federal Government. Now, in the past, they didn't always work together. But if we're going to attack climate change, if we're going to attack the need for better batteries for electric cars, if we're going to attack the need for quantum computing, we have to have a coordinated effort. We need NOAA, and NIH (National Institutes of Health), and CDC to work together on climate change. We need DOE, NSF, and DOD working together on batteries. So that requires more coordination that we've ever had before, so we've got to do both those things. We've got to be able to invest heavily, you know, and that's going to be a lot more than we're doing today. As Mr. Quaadman said, we should be doing way more in terms of GDP in research and development, but the second piece is we've got to coordinate our activities in a way that actually attacks the problems that we're trying to solve.

Mr. KILDEE. Thank you. I wonder, Mr. Quaadman, if you could comment, but also specifically any thought you have on the necessary incentives for private sector investment? Like, for example, the change in the R&D tax credit that'll go into effect in 2022, what impact that might be having in terms of the way those—that expensing will be amortized. Are we providing the proper incentives? Did the *Tax Cuts and JOBS Act* actually work against us, in the sense that it changed the way companies can to look at that investment?

Mr. QUAADMAN. Yeah, thank you very much for that question, Mr. Kildee, and I would just say too when the Chamber released its climate principles in mid-January, last month, you know, two things that we had in there is we have to embrace technology and innovation to address climate, but then we also need to ensure that there's U.S. climate science leadership to address the problems as well. So I think the *American Energy Act*, as an example, provides for funding for a number of different technologies, such as advanced nuclear, carbon capture, a number of other things that can—that could help lead us through that.

I would also say too—No. 2, to your point, it is very important that we do change that R&D tax credit. That is going to be very important for how business will allocate funding. But the last point I want to make too, which it has come up in a couple other ques-

tions, but I think undergirds a lot of this, Federal research is also important. Some of what we've talked about with the COVID vaccines, there is 2 decades of research that went into mRNA before we even got to the vaccine. If we take a look at GPS (Global Positioning System), that research started in the 1950's. So we also have to understand too, there could be decades of research in the basic research field where the Federal Government plays a unique role that the private sector and the academic researchers can come in later on, when we're talking about applying the development research. But really it's that core that we need to get going as well.

Mr. KILDEE. Great, I appreciate—my time's expired. I really appreciate the testimony of the witnesses, and, Madam Chair, I appreciate you holding this hearing, and I yield back.

STAFF. Mr. LaTurner is next.

Mr. LATURNER. Chairwoman Johnson, Ranking Member Lucas, thank you for having this hearing so we can discuss the importance of research, and the United States remaining at the forefront of the world of science and technology. One of the key reasons the United States became a world power was the emphasis we placed on innovation. We invested in research and development in the universities like the University of Kansas (KU), which I am so proud to represent, and national laboratories as well. We led by example in scientific and technological advancements. But now others in the world are emphasizing their research programs, and are working hard to overtake us. China is pursuing aggressive plans to become the world leader in technology, supplemented by their own national policies, and billions of dollars in investments.

It comes as no surprise that national research efforts were among the many things impacted by the COVID–19 pandemic. Laboratory closures, health restrictions, and cancellations of conferences and travel have strained researchers and disrupted our normal operations. The virus has lowered our research output, cost hundreds of millions of dollars in divestment, and nearly halted the academic research and STEM workforce pipelines. If we want to come back from this, and stay ahead of China, we must look to getting our research enterprise back in full working order, and ensure there is a place for our future generations of researchers and innovators. I hope that this Committee can come together to make sure the rest of the world looks to America for future scientific advancement.

Mr. Quaadman, partnerships between the Federal Government, academia, and the private sector are commonplace in our national R&D or enterprise. Can you discuss the importance of the public/private partnership, especially as it relates to overcoming the COVID situation that we've been in over the last year?

Mr. QUAADMAN. Yeah. I think it was very important that we had the ability of the Federal Government, academia, and the private sector to come together extremely quickly to ensure that there were either research dollars in place, or that there were deployment dollars put in place, as well as a sharing of knowledge, which we talked about the computing consortium as an example of that.

We've—we saw—frankly, we also saw that in the 1960's through large agreement with the moon program as well. So it just goes to show, if we get our act together, and can work in concert together

to ensure that we are putting our best foot forward, nobody's going to beat us. The problem we've had over the last several decades is, you know, we're sort of riding along on some successes that we've had in the past, but we did not have a concerted strategy, and I think we are at a point here where we could sort of take a little bit of a deep breath to make sure we get things back up and running, but also look at the long term as to what we need—what policies do we need to put in place to make sure that we are going to continue our leadership.

Mr. LATURNER. I appreciate that. Dr. Keane, the University of Kansas is the largest employer in the Second District of Kansas, and one of the largest employers of the State. Researchers at KU, like most citizens in the country, have had great restrictions to return to work. What I'm concerned about is that grants that have been awarded in the past can't be completed, and the potential for new scientific discoveries will stall. Can you speak to the type of impact legislation like the *RISE Act* would have on the university research community, and how that can affect the larger communities and cities that universities reside in?

Dr. KEANE. Thank you, Representative LaTurner, for that question. It's a great question. The *RISE Act* will definitely help the situation. We talked earlier about the 20 to 40 percent loss in output. It's essentially due to, you know, the time out we've had, and then looking ahead, the difficulties in ramping up again. So the *RISE Act* will support researchers that will allow us to come back fully, and that will support the local economic development within those areas. As you know, universities are very strong engines in the local economy in their various communities, certainly in my area in rural Washington. So I would strongly urge that we—that the Committee pass the *RISE Act*, provide the resources to enable that research to finish that was interrupted. And I think also, as we've heard, we need to look to the future as well.

If I could also just for a moment emphasize as well some of the issues with HBCUs (Historically Black Colleges and Universities) and others on this, they're in a particularly tough spot because they don't have a lot to fall back on in terms of infrastructure and other things, in terms of getting the full range of our talent. They, as well as—faculty, as we've already heard, have been particularly strongly impacted, and deserve attention.

Mr. LATURNER. I appreciate that, Dr. Keane. Thank you, Mr. Chairman, thank you Ranking Member Lucas. I yield back my time.

STAFF. Mr. Casten is next.

Mr. CASTEN. Thank you very much, Madam Chair, and I feel like I need to apologize. We have such a good bunch of speakers, I would love to ask the same questions of all of you, because I think some of the differences in nuance would be interesting, so if you want to follow up, please do. But I'm going to pick, for totally selfish reasons, as a biochemical engineer and biochemist, I've got to represent, so I'm going to go with you, Dr. Parikh.

I want to follow on the discussion you had with Mr. Tonko, and this, you know, that we've seen this falloff in research, and it's been focused on specific sectors, and I, you know, I think a lot have covered that, and I don't want to dwell on that, but what I'd like

to understand is—we have—science is an international endeavor. There's lots of collaboration between labs. For a whole lot of reasons that we don't need to get into here, but we can acknowledge, COVID affected different countries very differently, the rate of mask uptake, the rate of social distancing, deployment of testing, and particularly in the Southeast Asia region, including Australia and New Zealand, the reality of COVID was much less grim, as far as what it meant for social distancing than what it was here. Of those sectors of our scientific endeavor that have been most deeply impacted, have any of them been able to work with their collaborators to move that research overseas, and if so, will that research come back to the United States after, or is there a permanent loss that's there?

Dr. PARIKH. Mr. Casten, that's a terrific question. I don't have hard data on numbers of projects that may have moved, but certainly, at the individual peer to peer level—look, these conversations are happening all the time. We've got scientists here that talk to their collaborators. Maybe they're former students who are in Europe now, or who are in Australia now. And basic research works in a way where we do share information, we do share reagents, we do share intellectual conversations, because the point is to actually do the basic research so you can get to the intellectual property. And so that is happening.

There's no doubt that when experiments can't happen here, as a graduate student, I'd be wanting my idea to flower somewhere, because I have the intellectual ownership of that. Maybe not IP, but intellectual ownership of it, and so that is definitely happening. And right now it's manageable, because we can keep these students in the pipeline with funding like the *RISE Act*. What happens—what could be bad is if we don't do things like the *RISE Act*, we don't ensure that that pipeline gets unclogged, if those students follow those projects, those students follow those ideas, or they just leave the sciences. And that's what—that's a true worry for us.

Mr. CASTEN. So let me go from a mildly complicated question to a really complicated one, and put you on the spot with the clock at 2:30 and counting. When we think about the economic downturns, you know, there's—and I know the metrics on economic downturns. It's harder in science, but, you know, we'll see a collapse in the economy, and on a good downturn, "good", we sort of restore to the historic growth trajectory. So if you think about, like, the dot com crash, we got—we came down, and we got back—so we saw some above-average growth. In a bad downturn, like the 2008 crash, we fall off and we, you know, maybe we return to the historic rate of growth, but we never get back to that historic trajectory.

Dr. PARIKH. Yeah.

Mr. CASTEN. The reason I ask about that sort of international—not just the brain drain, but if the research has moved overseas, is there, you know, as you think about the restoration of—where we are, are we—is this going to be a good downturn or a bad downturn, from a scientific perspective? And from a policy perspective, beyond throwing money at the problem, which I'm sure we will, are there policy tools that we should be thinking about right now to make this a good downturn in the scientific? That make sense?

Dr. PARIKH. Yeah, absolutely. Absolutely, and——

Mr. CASTEN. And, again, if any of the rest of you have answers, please send them in writing, but I—time here after Dr. Parikh is done.

Dr. PARIKH. I appreciate that. No, I think it's an excellent question, and what we do here is going to determine what happens. I mean, we are at this inflection point. We're—we can't just move some money at it, and move on, and yes, we'll keep that historical trajectory, I hope. But, in reality, others are moving in the environment as well, so we have to do a couple of things. One is the investment. The second is that coordination factor I'm talking about. We haven't done that before. It is so important that we—if we're going to say that climate disruption is important to us, we've got to coordinate our activities. If we're going to say that batteries are important to us, we've got to coordinate those efforts between the academic environment and business. If we don't do that, then we're—our unconsolidated work is going to be incredibly powerful, and yet the sum will not be greater—the whole will not be greater than the sum of the parts. We've got to have that coordination.

So I think that's the policy issue. As we get out of the pandemic, and as we—if we save this generation of human capital, then the next thing is we've got to be able to coordinate our activities, otherwise we can't—a plan beats no plan. The Chinese have a plan on these things, and we have some on some areas, because of good legislation from this Committee and others, but we've got to make sure that we're thinking about this in a holistic sense.

Mr. CASTEN. Well, thank you so much. I see I'm out of time, but would love to continue the conversation with you and your staff—and, again, sorry to the rest of you that I didn't get to talk to, but we'd welcome them as well, to the extent you have a point to add. Thank you, I yield back.

STAFF. Mr. Gimenez next.

Mr. GIMENEZ. Thank you, thank you very much, and I want to thank the Chairwoman and the Ranking Member for putting this together, and everybody that's been on the panel. The question that I have is something that Mr. Parikh said, something about the supply chain. Does talent follow the supply chain?

Dr. PARIKH. Does talent—thank you for the question, Mr. Chairman. I think talent follows the opportunity. You know, in times when the finance industry looks like the place to be as a young person, people want to go to the finance industry. And you are—you're so influenced by your parents. And I just had a conversation with a program in the south side of Chicago, and—we're trying to get young people interested in the sciences. They only get interested if they know there's a job there, that there's a life there. And so, yes, it follows the opportunity, as much as it follows the supply chain.

Mr. GIMENEZ. So if the supply chain is leading, or left the United States, and we want to get some of this talent back, would it be a good policy to try to bring the supply chain back to the United States?

Dr. PARIKH. I'm following your question now. Look, absolutely, because the more parts of the supply chain that are here, there are more jobs for that talent. They can work in manufacturing, they can work in the translational sciences, they can work in—on the

policy side related to the manufacturing, so absolutely. I think that's a true statement.

Mr. GIMENEZ. How can we incentivize the supply chain to come back to the United States?

Dr. PARIKH. I'm going to defer to Mr. Quaadman on part of that, because he is the—he's much more of an expert on the industry side. What I will say is that, you know, the investment in research, if you notice these areas around the country, the geographic areas, the clusters where science is happening, a lot of time the translational stuff happens around there as well, and then you can see the manufacturing. But I'll defer to Mr. Quaadman on the—on details.

Mr. GIMENEZ. OK.

Mr. QUAADMAN. Sure, Mr. Gimenez. Thank you for that question. That's an excellent question, so let me answer it in two separate ways. No. 1—came out with—report with China, and one of the things—recommendations that was made in there was also to increase our domestic manufacturing base, and I think the *CHIPS for America Act* is a very good example of that. And we can send you a copy of that report, and have a further discussion with you on that. Second, we are also looking at President Biden's Executive order from yesterday. We fully agree with the aims of having a resilient supply chain, and a diversified supply chain, and we also look forward to providing our—on that as well.

Mr. GIMENEZ. OK. Shifting gears a little bit, you know, the pandemic has been horrible, but also it's taught us a different way of doing business. And so is there any upside here for research, in that the pandemic has forced us to conduct business in a little bit different way? And maybe it's been positive on some research, and it's been negative on others, so what's been your experience?

Dr. KEANE. Representative Gimenez, if I could take a crack at that one for a minute? First of all, I think we've all learned a lot about but—about virtual techniques, and some of them are just going to remain, as you might imagine, certain types of meetings that will become virtual forever. They actually are more effective at promoting diverse input. I think we've also learned some other things, not just associated with remote technology and—things like artificial intelligence. The Allen Institute for Artificial Intelligence out here in Washington State, their leader put together a body of papers on COVID–19, 200,000, analyzable by some of their machine learning platforms and so on. So, essentially, it's as if you could draw on 200,000 papers to get an answer you're looking for, which is obviously a faster rate of progress than most of us human researchers could do. There have some major changes that have happened, some very positive advances out of this crisis, and so I think there'll be a lot of great advances that'll be incorporated into the research enterprise in the future. Thanks.

Mr. GIMENEZ. Well, last question, since I'm new to this Committee, where do we stand in terms of artificial intelligence research here in the United States versus probably our main competitor, China?

Dr. KEANE. I'm not an expert in that, but I will just say that the advances—there have been advances in machine learning due to some advances about 4 or 5 years ago, and so the applications of

AI right now are exploding. It will fundamentally change how we conduct research, and lots of other areas of our lives.

Mr. QUAADMAN. I would just add too that is the jump ball of the 21st century, as to who's going to win that. And I think we're taking some very good steps to ensure we've got the policies in place so we can help with the development, we can help be a leader there, but by no means are we assured of winning that race.

Mr. GIMENEZ. I know that my time is up, and so thank you very much, but I'll just close by saying that I think you're right, the race to artificial intelligence is the jump ball of the 21st century, and we need to win it as a nation. Thank you. Thank you very much, Madam Chairwoman.

Dr. LEVINE. If I could just add one dimension on that point quickly? One of our potential competitive edges is that AI needs the kind of modeling and development that takes into account the diversities of reasoning and decisionmaking. And what we have in our democracies, and in our commitment, hopefully our renewed commitment, to equity is to bring those voices into the AI community. There are many very central locations already doing that. It's the kind of thing we need to invest in, and that's where I think our competitive edge can reside. We don't think in one way, and we need to bring that diversity of reasoning into modeling in AI. It's happening now, and we need to invest further in it.

STAFF. Ms. Ross is next.

Ms. ROSS. OK, I've unmuted. Can you hear me?

STAFF [continuing]. Can.

Ms. ROSS. That's great. Well, thank you, Chairwoman—and—Member Lucas. It's been a—hearing, and it—it's—much from research dollars going to our universities, and also going to several of the organizations that do research. We're now ranked among the top 10, I believe No. 6 in the country, and I have North Carolina State University in my district. I also have two HBCUs in my district, and I really appreciate the mention of the HBCUs, because they are doing excellent work, and are educating the next generation of entrepreneurs, so I want to thank you for that.

My first question is for——

STAFF. Ms. Ross, you appear to be experiencing bandwidth issues, and your connection is cutting in and out. You may want to turn the camera off, and that may help with your audio.

Ms. ROSS. OK. No. OK. OK. I'm sorry about that. I'm going to have to yield back.

STAFF. OK. We'll go to Mr. Obernolte.

Mr. OBERNOLTE. Well, thank you very much, and thanks to our witnesses. I've really enjoyed the hearing. One recurrent theme that has surfaced in the testimony seems to be concern about our investment in research and development compared to China's, and how that might undermine our strategic position. That's a concern that I very much share, and so I had a couple questions regarding that.

First, to Dr. Keane, you quoted some very interesting statistics about how we were falling behind China in our investment in research and development, and I'm wondering, are those statistics including both private and public sector investments in research and development? And, you know, kind of as a follow-on, it seems to me

that measuring private sector investment in R&D in the United States is actually a little bit problematic because it's not something that's always reported. You can get it from publicly traded companies' disclosure statements sometimes, but quite often that's a trade secret that companies don't share. So how confident are we in those statistics?

Dr. KEANE. Yeah, thank you for that question, Representative Obernolte, great, great questions. First of all, the source of that data, as I mentioned earlier, I believe is the National Science Board Indicators Report, which is based on the survey data that the National Science Foundation collects from industry, universities, all manner of folks that perform research. So the answer to your first question, then, is that those numbers include all research, federally funded universities, industry, nonprofits, et cetera, and all those folks typically respond to these survey—NSF.

With that said, your question about the quality of the data, I don't have an NSF colleague here, but, you know, we could certainly connect you with someone to talk about that, and how they collected—but it is all expenditures from all sectors, and it is based on a—it's currently a systematic survey that's been done for many years by the National Science Foundation.

Mr. OBERNOLTE. All right. Thank you. You know, not to say that the data's invalid, something I'm very concerned about, but to be able to solve the problem we need to make sure we get our arms around exactly how big the problem is, and because our economy is much less centrally planned than China's I'm concerned that we don't have a full picture of what our private sector investment in R&D is.

And then, for my second question, to Dr. Quaadman, basically on the same topic, but you had said something I found very interesting in your testimony, expressing concern that in the past most research and development was publicly funded here in the United States, and that now that's kind of flip-flopped, and we're 70 percent privately funded, and only 30 percent publicly funded. And I'm wondering if you could defend a little bit, you know, why you're concerned about that? Because it seems to me that, you know, maybe there's a difference in the type of research going on. Maybe public funding is more toward basic research, and private funding is more toward applied research. But, you know, why is that something we should be concerned about?

Mr. QUAADMAN. Well, because—think of it this way, all right? Because the—a lot of the business funding, it's either in development research or it's in applied research, right, where you're trying to develop products off of other research that's—theoretical—or from the basic research arm. So if you're not doing some of that basic research, you're not going to get some of those other impacts. So if you think about it this way, in the example I used earlier, with GPS, right, that started with the Federal Government in the 1950's. Think of all the different ways we're using GPS now. By the way, with the implementation of 4G, with data localization and sharing, et cetera, that's how you got ridesharing, right? And we would sort of say now, like, going into an Uber and a Lyft, that's sort of second nature. So now if you look at it this way as well, as

we start to implement 5G, what are going to be the products that come after that?

The point is, if we're not doing that basic research, you're not going to have those positive benefits—societal benefits that occur due to some of the development research that happens, and that's when you start to look at what—as we are, not spending as much on the basic research. We're not going to have that bang for the buck later in the future.

Mr. OBERNOLTE. Sure. I agree with you, however, I think it's kind of a nuanced point. Basic research is sometimes the most easily duplicated. Applied research is very difficult to duplicate because you're, you know, you're applying it to a specific application. So——

Mr. QUAADMAN. Um-hum.

Mr. OBERNOLTE [continuing]. I mean, I actually think that this is something that we as a nation should be talking more about, because I think it's an incredibly important topic to talk about, what kinds of research we're funding, who is funding it, if it's public sector or private sector, and how that stacks up against other countries, particularly China. But thank you. I see my time's expired. Thank you very much to our panelists. A really interesting discussion, I look forward to continuing it in the future. I yield back.

STAFF. Ms. Bonamici is——

Ms. BONAMICI. Thank you so much. Thank you, Chairwoman Johnson and Ranking Member Lucas, and thank you so much to our witnesses for joining us today. I—I've now relocated to a computer where I'm not going to be dropped, I hope. So I really appreciate the Committee's continued focus on the effects of the pandemic on our Nation's research enterprise following our hearing last fall on the needs of universities and I'm very glad that we're securing funding for the National Science Foundation and NIST, the National Institute of Standards and Technology in the American Rescue Plan, but we need to pass the *RISE Act* to truly recognize the expenses and the challenges that have been accrued in ramping up, or down, spending, and then eventually restarting Federal research. So today I want to focus on the long-term consequences of the pandemic for the research community, specifically for our workforce, in solving the next moon shot challenge.

But I also wanted to note that, you know, this Committee has had countless hearings over the years about how to grow and diversify the workforce, and STEAM (science, technology, engineering, arts, and mathematics). I say STEAM intentionally. Mr. Quaadman mentioned innovation, which is critical, and there was a suggestion along the way that—interested in the arts should be redirected to STEM. I submit that the better solution is integrating the arts into science, technology, engineering, and math. Brain research shows that arts education helps students be more creative and innovative, and Europe and Asia are not cutting the arts.

So I'm—I do want to focus on the economic consequence of the COVID–19 pandemic, and how they have exacerbated so many of the inequities and the barriers facing women in communities of color. Because of entrenched gender roles, women are continuing to take up the majority of childcare and caregiving responsibilities. That's directly affected their research, as Dr. Keane mentioned.

One professor at the University of Oregon, Dr. Machalicek recently noted that she regretfully now deletes every request for a proposal because she simply doesn't have time [inaudible] caregiving responsibilities. She hosts an online writing group for—they have to be at night, after bedtime for—children.

Now, Dr. Levine, you noted several data points in your testimony that suggest that Dr. Machalicek is not alone in her experience. What steps can universities and the Federal Government take to support women in research fields to make sure that they aren't left behind as we get through the pandemic and build back?

Dr. LEVINE. What an excellent question, and that citation not only resonates with what we heard so powerfully in our focus group, but just looking at the top line, as we're bringing the survey into an analytic format, we're just seeing it pop off the page. We need to do something that provides much more comprehensive wrap-around services. That's one of the reasons why I mentioned early on that supplemental funding that NSF has, that should be a kind of thinking that leads to wrap-around support, potential childcare services, additional, potentially, RA (Resident Assistant) support, and other kinds of time off, salary release time, as a good way of catching up and that, and those who have elder care responsibilities.

And one of the reasons why I emphasize—this is particularly an issue for women of color is that one of the things we picked up in the focus group very clearly is how much additional family care, based on many first generation career scientists, then need to also not only invest in their own child care, but wrap-around care to their family members, so we need to——

Ms. BONAMICI. Thank you so much. And, Dr. Levine, I don't mean to cut you off, but I really want to get another question in to Dr. Parikh. And even in the midst of an unprecedented pandemic, the climate crisis continues. We need climate science to help mitigate and adapt. Oregon State University (OSU), in my home State, is home to a world class ice core analysis laboratory, and they rely on ice core samples from the national archive at the NSF ice core facility in Denver, so COVID restrictions on Federal staffing and travel have significantly slowed their access to samples, in particular for a new project studying what is believed to be the oldest pristine ice samples ever discovered. So OSU's research vessels have been restricted as well, limiting supplies—or, excuse me, samples, for algal blooms—temperatures of the ocean. These gaps are irreplaceable, so, Dr. Parikh, I appreciate your focus on our Nation's innovative leadership, but how will these disruptions affect our ability to solve challenging problems like the climate crisis?

Dr. PARIKH. It's an excellent point, Ms. Bonamici. It shows that, yeah, this goes beyond the biomedical research sciences. It goes beyond our challenges related to the here and now. It goes to future crises, and there's no getting back the time that that ice core couldn't move from Denver to Oregon. We can't get that back. What we can do is ensure that, going forward, we have the human capital that was going to do is still there, and the next generation's also coming, and that we also have thought about the resiliency of that scientific enterprise.

You know, we can—sometimes you think about these things, there are freezers that hold unique biological samples in this country. There are freezers that hold unique core samples from the Arctic. We need to make sure we have resilience in that—in those invaluable assets that only our Nation has because we invested the time, and the energy, and the resources to go get it. So let's make sure we have that resiliency in place as well.

Ms. BONAMICI. Thank you so much. I see my time has expired. I yield back. Thank you, Madam Chair.

STAFF. Mr. Babin is up next.

Mr. BABIN. Yes. Thank you very much, Madam Chair, and Ranking Member Lucas. I want to thank all of you witnesses as well today. This conversation we're having is critically important in many ways, but probably one of the most important are the implications that this has on our national security during this time of the pandemic. The U.S. Justice Department has accused China of sponsoring hackers who are targeting labs that were using state-of-the-art technology to develop our COVID vaccines. The Director of the FBI (Federal Bureau of Investigation) has said that acts of espionage and theft by China's government pose the "greatest long-term threat" to the future of the United States.

My first question goes to Dr. Parikh and Dr. Keane. There have been multiple examples of Chinese hackers attempting to steal COVID vaccine data from different universities around the country. In your opinion, how susceptible are our universities to Chinese hackers, and what do each of you see as being a solution to better protecting our technology and our research? Dr. Parikh, if you would answer first, and then Dr. Keane. Thank you.

Dr. PARIKH. Thank you, Mr. Babin. This is a critically important question. You know, I can attest that every one of our institutions, our national laboratory, even the AAAS, we are constantly under attack in cyberspace, and it's from multiple nations around the world. The challenge for us is to make sure that we are being—we are protecting our intellectual property, we're protecting the things that need to be protected for defense, as laid out by the National Security Directive—Decision Directive issued by President Reagan during the cold war, Directive Number 189. We need to make sure that we are protecting those assets, while balancing the need for collaboration. And, you know, basic research has collaboration that is required as well.

So in terms of policy, are—you're asking if the universities are better today than they were yesterday, they are. They are. Will they be better tomorrow? I think so. And part of that is that we are learning. We are constantly learning. This is a fluid situation. It has gotten worse over time, and the universities have been, in my opinion, and now I turn to Dr. Keane to answer directly, but, in my opinion, from the outside, they have been very responsive to this—to these attacks.

Mr. BABIN. All right. Thank you so much. Dr. Keane?

Dr. KEANE. Yeah, thank you very much for that question, Representative Babin. So let me first of all state that universities are actually dedicated to implementing measures to, you know, conduct our research in a secure manner. Just also a little bit of background, in terms of life under attacks, you know, as Dr. Parikh just

talked about, we're in a similar situation. Over 90 percent of the e-mails that we get at Washington State University are attacks or spam, so our firewalls are constantly defending us against all manner of things.

In terms of what we're doing about it, you know, a variety of things. First of all, we have, you know, significantly increased faculty awareness on this. We talk to our faculty all the time. We are improving our systems for disclosure of conflict of interest and conflict of commitment. Conflict of Commitment, the simple way to think of that is we want to make sure that a faculty member doesn't spend 100 percent time on one project, and then go out and get a grant to do exactly the same work with somebody else, right? And so we have systems in place that we—or monitor that, and we've gone to electronic, and other sort of ways to help us do that, as have many universities.

I also just want to close on this—my comment on this topic by pointing out that the recent legislation in the *National Defense Authorization Act*, and also ongoing efforts to try and harmonize research security related—across agencies. Right now there is significant administrative overhead because we have different requests—for example, interactions with China or whatever—country—in different formats from different agencies. So we spend a lot of time trying to sort out the different forms, which isn't, you know, value added. So anything that could be done by the Congress or the Committee to try and take a coherent multi-agency approach to research security would be welcome. Thank you.

Mr. BABIN. Absolutely. Thank you, Dr. Keane. Real quickly, Mr. Quaadman, in your capacity with the U.S. Chamber, how is the theft of basic research by China going to hurt our economy and our competitiveness? If you could just give a few seconds to that?

Mr. QUAADMAN. Yeah, I mean, obviously it's harmful to both. One of the things that the Chamber has done, through our Global Innovation Policy Center, in a few weeks we'll be releasing our 10th IP Index, which ranks each—ranks the top 53 economies as to their treatment of intellectual property. China and India historically have not ranked high there. They've actually ranked fairly low, for obvious reasons. What that has also done, though, that's also sparked a U.S./China dialog where we work with these issues with both business and government leaders, as well as with India. So part of our belief is that it's—it is important to shine a light on these problems because it creates incentives to try and address some of them from the other side as well.

Mr. BABIN. Absolutely. Thank you so much. I'll yield back, Madam Chair.

STAFF. Ms. Moore is next.

Ms. MOORE. Thank you so very, very much, Madam Chair, Mr. Ranking Member, all of our witnesses, Dr. Parikh, Dr. Keane, Dr. Levine, Mr. Quaadman. I have learned so much from this hearing today, and I have more questions than I do time, so let me try to get through this.

When we look at—I want to make a declarative statement, and then sort of get a response from you. When we look at the numbers of women who engage in research, I guess of any type, whether it's biomedical, or defense, or any other kinds, like, 30 percent globally,

and you've all attested to the fact that women have various family responsibilities that Dr. Keane said keeps them out of academia for numbers of years longer, they don't go into research because of the framework of being family, and so on. I just want to know, is there anything about the *RISE Act*, or other sorts of research, that specifically focuses on maintaining these women, and now that we've gone through this pandemic and seen some slippage, is there any very specific plans with the universities, or with research firms, or Chamber of Commerce, is there any specific research that focuses on maintaining women?

And I don't say this out of some sort of just abstract notion of we need affirmative action. I mean, it matters, and it matters a lot, whether women and minorities are engaged in these kind of programs. I'll just give you an example. I took a—kind of a blood pressure medication, and my mouth swelled up, and I was looking all ugly, and I called one of my friends, who's a Black female cardiologist, and she said, you—as a Black person, you should've never been taking that medicine in the first place. And—so the consequences of not having women in the field—and I want you to talk about that. And then there's been a lot of talk about national security issues, and I notice that women in the Soviet realm, and perhaps even in China, much higher participation of women in research. Want to know if that has any implications for national security, or for our keeping pace. And so I guess I would ask that of Dr. Parikh, Dr. Keane, Dr. Levine.

Dr. PARIKH. Ms. Moore, thank you for the question. My goodness, the value of having diverse voices at the table, women, underrepresented minorities, is not just because of the moral imperative. The moral imperative is obvious. The real reason is because it actually helps our economic competitiveness, and it creates solutions, so the example you gave is a perfect one. When we talk about solutions to this, they are—we've got to aim it at every spot in that pipeline. So, for the kids, K–12, we've got to make sure they're not getting the signals—the wrong signals, to get out of the sciences. We've got to make sure they're getting interventions to help them if there are challenges that are keeping them out of the sciences that are not related to study. Got to make sure we're intervening there.

And then, at the graduate school level, we have graduate students that are in their 20's, and we have post-docs in their 30's. They need to not just be treated as apprentices. They need to have some benefits that are employee-like because they are of the age to have children. They are of the age to be married. We need to make sure that they have those kinds of benefits. So I think those are a couple I've given out. I'll give to—time to the others as well.

Dr. KEANE. Yeah, if I could comment, Representative Moore? Great question. So the answer to your question is, yes, there is research going on to try and actually come up with real ways to improve the situation. But one of the things we need to do, obviously, as a first step is to think about, you know, why are we in the situation we're in? And, to that end, just as an example, there was a very recent, just—think this last month, a study that came out by the National Bureau of Economic Research that surveyed 20,000 Ph.D. woman respondents about their lives, and that turned up

some interesting facts, you know, such as on average women have lost double the time to research that men have in the pandemic. And also we can see, by looking at large scale data and publications, that women are definitely publishing less than men.

And I know—but that is also just a whole number of potential ways to improve the situation, universities extending tenure clocks, waiving certain types of service for women, providing care, and other, you know, the—relieving other forms of faculty service so women can focus on research, OK? So there's a whole bunch of ideas in the pipeline to address this question.

Dr. LEVINE. Well, I'll just add a couple of words to that, because those are, you know, the important points, I think, to drive home to an exceptional question. I think that we also need to recognize that—hierarchy and positionality, often of women in the workforce. We have, you know, we are very aware that in leadership roles women can be silenced in subtle and not so subtle ways. So they can be central to a team, but not yet rewarded in the same way, so that—we have to understand the nature of the work, because women as scientists are often more inclined toward collaborative models so that—if the pecking order is sole author, versus multiple author. So this is a really important broader issue that we need to take—consideration.

While we support, for example, expanding and extending the tenure clock during this time, and accounting for different kinds of activities, we also need to be sure that the status hierarchy doesn't backslide and say, 3 years from now, so what happened? You know? So we have to be very attentive to the—to essentially subtle indicators that may not seem to leave women behind, but after all they have an adverse—and for women as well—of color as well. A great opportunity and challenge for all of us together, and in collaboration with this Committee, and its sensitivities, and higher education and research institutions.

Ms. MOORE. OK. Thank you. I yield back. Thanks for indulging, Madam Chair.

STAFF. Mr. Gonzalez is next.

Mr. GONZALEZ. Did I hear Mr. Gonzalez? I'm sorry, I thought I heard it, but I don't want to jump the gun.

STAFF. Yes, you're next.

Mr. GONZALEZ. OK, great. Well, thank you, Chairwoman Johnson and Ranking Member Lucas, for holding this hearing today, and to our distinguished witnesses for your testimony. As those who served on this Committee with me last Congress know, I personally believe that appropriately funding and supporting our research enterprise is among the most important things we can do for our economy long term. You know, we tend to solve problems that are sort of staring us right in the face, but the truth is the investments that we make in our research enterprise are ultimately going to create jobs 5, 10, 20, 30 years from now. And so I look forward to partnering with my colleagues in making sure that we're continuing to increase funding where appropriate, focus that funding so that we can invent the transformative technologies of the future that will help us sustain our economy, and continue to lead across the world.

Mr. Quaadman, as you know, China and other economies are investing aggressively, particularly in the industries of the future, like 5G, AI, quantum. Can you describe what steps the U.S. needs to take to remain a leader in the industries of the future, and what concerns do you have if we fail to do that, and cede that ground to a China, or another country?

Mr. QUAADMAN. Thank you very much, Mr. Gonzalez, and, first off, let me also thank you for your co-leadership of the Artificial Intelligence Caucus as well, and your leadership on these important issues. Look, I would say there are a number of different things here. No. 1, we're clearly in a race. I think I read recently Art Schmidt's testimony before Congress recently, where he said that the United States may only be 1 to 2 years ahead of China in terms of artificial intelligence research.

I think some of the steps taken last year, both with the passage of the *National Artificial Intelligence Initiative Act*, where we created a framework, both in terms of public and private partnership, to help incentivize that research, and provide some funding, is important. I think the OMB guidance released at the end of last year also helps with that, because we need the funding on the one side. We also need to have the collaborative atmosphere that allows for that development to take place.

Lastly, though, whoever wins that race to be the leader in artificial intelligence is going to set the standard, so NIST has a very, very critical role, if we were to be in that position, of developing what those standards are around the artificial intelligence, how they can—how it can be used, how it could get deployed. And that's very important because we bring in all the different stakeholders in a very collaborative effort to do that, and there are a lot of thorny ethnic—ethic issues associated with that which impact personal liberty, freedom, et cetera that we have very highly developed attitudes and values around that others may not. So we—that's one of the reasons why it is very important for the United States to be in that leadership role.

Mr. GONZALEZ. Absolutely. And one thing that I've seen proposed, that I think is a good idea, and I hope we do it, is to create some sort of G7, plus Australia and New Zealand maybe, standard-setting organization or body that could help inform how these technologies are developed, and what the values are that underpin them. Just as a concept, what are your thoughts on that concept? Feel free to disagree with me. I will not take offense.

Mr. QUAADMAN. No, I would say two things. One is I think that's an interesting idea, because if you take a look at it within the scope of the G7, and Australia, and New Zealand, there are a lot of those shared values that we have that can be helpful in terms of doing that. The other thing, I think we would just need to really think this through as well, is that, you know, the EU's also a competitor, right? So I think there has to be a decision if we're going to collaborate on that. And if it's going to be competition, that's fine, right? I mean, the United States does very well when it competes, but we have to realize we are competing, and that if we need to win this race, it's no different than the race to the moon, or to some other technologies that we made sure we were leading in in the 1960's, 1970's, or 1980's.

Mr. GONZALEZ. Absolutely. And then with my final question—well, we won't be able to get into this in 30 seconds. Maybe I'll submit it for the record. But one thing I am concerned about is our human capital development here in the U.S., and the feeling that, you know, some other countries are outpacing us in the development of our human capital, and I want to make sure that we're always in the lead there, and so I look forward to partnering with all the institutions here, and the Members of Congress on making sure that the U.S. is always as competitive as humanly possible. To your point, if we can compete on a level playing field, we will win. And with that, I yield back.

STAFF. Mr. Sherman is next. Mr. Sherman's recognized.

Mr. SHERMAN. Why thank you. Madam Chair, thank you for bringing us together. The importance of science was illustrated to the entire country over the last year, as we deal with this COVID crisis. The response of the science community hasn't been perfect, but given the sudden and unexpected nature of this, has been very good. We haven't always followed the science, but we will straighten that out as well. And the vaccines that are coming to us are as a result of the scientific knowledge that has been put together over the last decades. That's why it's important that we move forward with the *RISE Act*, to keep research going, and to preserve our research capacity for the future. And I thank you for introducing that legislation.

We have—others have talked about artificial intelligence, and I just want to point out how important it is that it's kept under human control, and that we engineer into the basic elements of artificial intelligence. You can't just add it in at the end, get it into the hardware, into the systems, in avoidance of self-awareness, in avoidance of ambition, or a desire to persevere. When we talk about promoting science, naturally we're the Science Committee, and we focus, usually, on what's government doing, the space program, our grants to academic research. But we've got a limited amount of money, and I'm sure what money we have for science we will work hard to make sure it's spent in the best way.

But there's a much larger amount of money, and that—and the best practical research is often done by our private sector with their own money. And we tend to focus on the startups that have no revenues, and they will, of course, do research. That's their whole reason for existence. They only, you know, money comes as invested by the investors. The only thing they're going to do with it is spend it on their startup research. But the vast majority of private research is being done by companies that have revenues that are expected to earn a profit. And so if you want to influence how much of that research is done, you have to look at our accounting system, at—because Boards of Directors get up in the morning, and they say, how much can we show as earnings per share?

We had an accounting system up until 30 years ago in which we treated research appropriately, as we had for the past 200 years. We made a mistake, and this the first time in this Committee that I'll say that perhaps the greatest threat to research is based in Norwalk, Connecticut. That is the location of the Financial Accounting Standards Board (FASB), a governmental agency that often argues that it's not a governmental agency. Mr. Quaadman,

we have, over the last 30 years, a system where if you invest money in a building, that's not an expense. It doesn't hurt your earnings per share, it's investment. But if you invest money in a research project, that's an immediate expense. It hurts your earnings per share, and makes you look worse than those of your competitors who aren't spending money on research. Can you give a feel for how much this impacts the amount of money spent on research by corporate America, focusing not on those few startups, but on the big companies that are expected to show a profit?

Mr. QUAADMAN. Yeah, thank you very much, Mr. Sherman, and thank you for your leadership, both for investors and for capital formation as well, and your doggedness on this issue, because I know you've been after this one for decades. Let me start here in terms of—we have to separate tax policy out from accounting policy, because they're two different things.

Mr. SHERMAN. I'm just focused—I just——

Mr. QUAADMAN. Yes.

Mr. SHERMAN [continuing]. Interrupt you, we invest billions of dollars over in the Ways and Means Committee promoting research——

Mr. QUAADMAN. Yeah.

Mr. SHERMAN [continuing]. But what I'm talking about is the accountants based in Norwalk, Connecticut pushing us in the other direction. Go ahead.

Mr. QUAADMAN. Agreed. Our CEO, Tom Donahue, in 2005 gave a speech at Nasdaq where he raised concerns about companies trying to hit the quarterly earnings guidance, right, within a penny or two, right, and that there are polls that actually show that businesses would make decisions that run counter to, let's say, their long-term capital expenditures. In terms of the first principle for the Chamber in terms of accounting, we always believe that it's important to start from the place of—that, you know, financial reporting needs to reflect economic activity, and not to drive it. Additionally, we've also called for, for years, about the need for a cost benefit analysis in the determination of accounting standards, that we actually have data to understand this along the lines of the problem that you're raising.

So I believe that Russ Golden, in his last days as FASB Chair, testified before you at your Subcommittee about looking at intangibles, which this gets into, and I think there needs to be—we need to have somewhat of a data-driven discussion around that to determine what the extent of the problem is that you're raising, and what we have—what we would have to do to sort of—what we'd have to do to address it.

Mr. SHERMAN. My own work makes me think that we're talking about hundreds of billions of dollars in research that would otherwise have been conducted over the last 25 years had they not made this bad accounting decision. I yield back.

STAFF. Mr. Meijer is next.

Mr. MEIJER. Thank you, Madam Chair, and Ranking Member, and to our witnesses here today. I really appreciate the time for you to share your thoughts and experiences. Obviously COVID has created disruptions across our Nation, but ensuring that we bounce back as rapidly as possible is key not just in our academic settings,

not just in our economic settings, but also in our research and development settings.

I've been speaking over the past several months with members of the Michigan research community, both those at the Panhandle Institute in my district in Grand Rapids, at Michigan State University, at the University of Michigan, at Wayne State University, and other institutes of higher education throughout the State of Michigan, to see what we can do to ensure that a lot of the critical research that they've been conducting, you know, as they had to scale back staffing hours in the labs, as they had to deal with, you know, perishable equipment and supplies, on how we can make sure we bounce back as quickly as possible. And I just want to address this to the witnesses in general, and please feel free, any of you, to respond. I guess how are researchers best adapting to the new environment that's been created by this pandemic?

Dr. KEANE. I'll—if I could—I'll take a quick cut at this——

Mr. MEIJER. Yes, sir.

Dr. KEANE [continuing]. First. So thank you—thanks, Representative Meijer, for that question. It's a very important one. You know, the short answer is in many ways. I think people are learning how to make effective use of virtual tools for a whole bunch of reasons, in a whole variety of ways. I think we're also learning how to conduct research in our laboratories with different staff. You know, we can come back at some of these laboratories now at lower staffing levels. We've gotten much better figuring how to use equipment, and actually conduct work on the situation.

There's some things that are harder than others to deal with, such as human subject research, which, you know, has really come back in things like biomedical research in particular, haven't quite come back because of the close nature of interaction. You know, but overall the enterprise—we estimate at WCU, and my colleague, DPR, is elsewhere, we think we're sort of at 60 to 70 percent of prepandemic at the moment, but the remaining things are hard to crack. But we—as I mentioned earlier, we still have to worry about finishing off all the work that was delayed. Before we—it was very helpful to have flexibilities and no-cost extensions, but to finish the work has a cost. So, anyway, that's the quick answer. Thank you.

Mr. MEIJER. I know, and I appreciate that, Dr. Keane. I guess, just building on that, you know, we've already, you know, kind of touched upon, kind of in length, some of the funding concerns, but in terms of other concerns, are there policy modernizations that you feel are needed to make sure I guess specifically at the Federal level to make sure that U.S. researchers remain competitive and grow? Are there any gaps that have really been created that they're concerned or that we may be able to address through a policy angle?

Dr. KEANE. I'll mention just one I did a few moments ago, because it's a topic of a lot of discussion right now, and that is the monitoring of international, right, and disclosures. We used to have very different and conflicting guidance from agencies, which is just—it takes us a lot of time to respondent to. I would—I will also say that a lot of our agencies have done a fantastic job responding and simplifying. Rapid, you know, proposal, review, and award processes have been immensely helpful, and should be encouraged

by the Committee, I would suggest, from a policy level, just as one of a number of examples of agency reforms that have been put in place and been very productive.

Mr. MEIJER. Thank you, Dr. Keane. And, Madam Chair, I yield back.

STAFF. Madam Chair, we have one other Member whose camera is on, but I don't see them. Ms. Wild, are you present? I don't see her. She would be our last Member, so I think we may be done.

Chairwoman JOHNSON. Well, thank you very much. Let me thank all of you who participated, and most especially our really great witnesses. This has been a very worthwhile hearing, and I know that we will probably have a follow-up sometime not too far in the future.

Before we bring the hearing to a close, I want to again thank our witnesses, and let you know how resourceful you have been. And the record will remain open for 2 weeks for additional statements from Members, and for any additional questions the Committee might have for the witnesses. Our witnesses are now excused, and the hearing is adjourned.

Mr. QUAADMAN. Thank you, Chairwoman.

Dr. LEVINE. Thank you.

Dr. PARIKH. Thank you——

[Whereupon, at 1:08 p.m., the Committee was adjourned.]

Appendix I

Answers to Post-Hearing Questions

ANSWERS TO POST-HEARING QUESTIONS

Responses by Dr. Sudip Parikh

April 12, 2021

The Honorable Eddie Bernice Johnson
Chairwoman
Committee on Science, Space, and Technology
U.S. House of Representatives
2321 Rayburn House Office Building

Dear Chairwoman Johnson,

Thank you for the opportunity to testify before the Committee on Science, Space, and Technology on February 25 to discuss "*Building Back the U.S. Research Enterprise: COVID Impacts and Recovery.*" As requested, I have reviewed the transcript and am submitting the following edits for the Congressional Record. My responses to the additional questions for the record follow that. Please let me know if I or AAAS can be of assistance.

Transcript Review Edits from AAAS:
1009: replace "grid" with "group"
1431: replace "[inaudible]" with "and by supply chains"
1460: delete "create"
1491: insert "been" between "has" and "that"
1497: replace "the" with "these"
1970: replace "--" with "industry jobs or into defense jobs, if"
2275: replace "true--" with "a true worry for us."

Questions for the Record and AAAS Response:
Sudip Parikh, AAAS, Response to Question Submitted by Representative Mikie Sherrill.
Thank you for this question, Rep. Sherrill. The uses, and potential uses, of AI in COVID-19 research, response, and recovery are indeed manifold. AI has been used to predict the structure of viral proteins and ease the analysis of the coronavirus literature. It can also be used to predict drug treatments or drive epidemiological early-warning systems to help prevent future pandemics. One general lesson is the importance of long-term investment in tools and enabling technology. Years of federal research and partnerships in AI have helped create the tools that researchers are able to exploit today, in the same way that years of basic biomedical research laid the foundation that resulted in speedy vaccine development. We're still learning the lesson of research in the age of COVID-19, including how to collaborate virtually over long distances, and how to quickly organize research networks and formalize agreements.

Sudip Parikh, AAAS, Response to Question Submitted by Representative Deborah Ross
Q1. Thank you for these questions, Rep. Ross. The impacts of COVID-19 on startups was in some ways severe, but also uneven. Census data suggests that business formation in April 2020 was 20% below the same point in the prior year. Among existing startups, surveys indicate that 40% were threatened with three months or less of cash runway at that point, and most saw slowdowns in financial backing and revenues, for some severe. The pandemic also resulted in a

partial slow in venture capital (VC) investment, and 10% of VC investors reported COVID-19 inflicted severe challenges in their supported businesses. However, following that difficult time, new business formation surged in the second half of 2020 and remains well above historical levels. This includes new business startups in scientific and technical services, and in manufacturing, which are two major sectors for R&D. PwC data also indicates the pace of VC investment has more than recovered to date.

Sudip Parikh, AAAS, Response to Question Submitted by Representative Deborah Ross Q2. There are a few ways that that investment in federal R&D catalyzes progress and economic growth. First is the act of discovery itself. Federally funded science creates knowledge that often finds its way into commercial inventions. Today the share of commercial patents associated with federal research is over 25%, and these patents often represent inventions of greater novelty in areas where industry has yet to sufficiently invest. Second, there's the tendency of federal R&D to induce additional follow-on investment, which itself can lead to new inventions, be it new software, materials, or pharmaceuticals. This can be particularly crucial for small firms and startups. At the same time, quality of R&D opportunities is a significant factor in the location choices of multinational industrial R&D funders. Third, federal funding is vital for human capital formation. Substantial portions of graduate students and postdocs rely on federal support, and university R&D as the training ground for the next generation of innovators is mostly funded by the federal government. Sustained, long-term support for all of these has meant growth in regional U.S. innovation hubs and manufacturing. Conversely, losing out on this support means reduced possibility for invention, fewer partnership opportunities for U.S. innovators, less incentive for industrial R&D investment, and reduced opportunities for young talent.

Sudip Parikh, AAAS, Response to Question Submitted by Representative Anthony Gonzalez Q1: Thank you for these questions, Rep. Gonzalez. Countries such as China have modified their methods of teaching K-12 science, focusing more on hands-on learning rather than rote learning. They have also been guided by resources developed by the AAAS Project 2061 and the National Academies of Science, Engineering and Medicine. There are many reports and surveys that demonstrate that while the U.S. still remains the leader in the production of science and engineering doctoral degrees, we are losing pace with other countries such as China. There has been a decline in the number of foreign-born students studying at U.S. universities, and the retention rate for Chinese and Indian citizens who earn a PhD in the U.S. is also in decline. Though the U.S. may not be able to compete with the number of citizens and sheer volume that some countries must educate, we can compete in creativity and innovation when it comes to STEM education. The AAAS and other organizations strongly believe that we can and must leverage the existing diversity of talented students in the U.S. to pursue and education in STEM fields.

Sudip Parikh, AAAS, Response to Question Submitted by Representative Anthony Gonzalez Q2: The AAAS R&D Budget and Policy Program has not studied workforce capacity with workload both in public and private sectors, nor have we conducted analysis to understand how COVID-19 impacts the functions of human resources departments.

Sudip Parikh, AAAS, Response to Question Submitted by Representative Michael Waltz
Q1: Thank you for this question, Rep. Waltz. The U.S. Congress should rely on the progress that has been made through legislative efforts such as the interagency working group established in the FY 2021 National Defense Authorization Act. That interagency working group was created with the express purpose of discussing policies for improving government coordination and actions to protect against intellectual espionage. The U.S. government has existing policies in place to protect the U.S. research enterprise, and it is critical to maintain the discourse and coordination among academia, research agencies, law enforcement and intelligence communities. Such discourse will allow for the development of appropriate policies that balance protecting research integrity, countering acts of espionage and advancing immigration policies that can allow the U.S. to maintain its innovation capacity.

Sudip Parikh, AAAS, Response to Question Submitted by Representative Jim Baird Q1: Thank you for these questions, Rep. Baird. At this time, the data, and investments in basic research on behalf of private industry versus universities or national labs may take years to fully understand. There are some initial analyses, such as the GAO study on federal contributions to Remdesivir. As I noted in my testimony, scientific discoveries are the result not of a single eureka moment but of years of federally funded research, the results of which we may not realize or utilize for decades to come. For example, researchers at the University of Texas at Austin and the National Institutes of Health (NIH) mapped the spike protein's structure within weeks of the release of the viral genetic sequence on January 10, 2020; their quick work relied on knowledge accumulated through years of basic research and led to record-breaking vaccine development for COVID-19.

Sudip Parikh, AAAS, Response to Question Submitted by Representative Jim Baird Q2: Yes, there were a number of basic research discoveries from years ago that contributed to our nation's ability to address the COVID-19 pandemic. The ability of industry to expedite the development of the various COVID-19 vaccines is a perfect example. Many comments have been made about the "overnight success" of mRNA vaccines from Moderna and BioNTech/Pfizer, but there is a 30-year story behind this success that is illustrative of why investing in science and technology is critical to the future.

The success of the mRNA vaccines is due to contributions from public and private sectors that include scientists at NIH, Moderna, BioNTech, and multiple research institutions. The ability of these small biotech companies to succeed is due in large part to the role that the U.S. Congress served between 1998-2003 when it made the wise decision to double the NIH budget. This enabled construction of the NIH Vaccine Research Center that was central to the vaccine story.

One of the research proposals that NIH funded during this time was one conducted at the University of Pennsylvania on the evolutionary origin of RNA. It's a seminal piece of research that went relatively unnoticed when it was published but ultimately made the Moderna and Pfizer vaccine platforms possible. At that time, one in three grant proposals were funded, enabling the pursuit of riskier projects. Today, less than one in five proposals receive funding. Without question, the mRNA vaccines are a product of increased investment in NIH. The

vaccines are a lagging indicator of that investment and a clear example of why the United States should again make the bold decision to invest.

Sudip Parikh, AAAS, Response to Question Submitted by Representative Jim Baird Q3: Over this past year, our journal, *Science*, has reviewed thousands of papers, and we have seen that research benefited from collaboration between multiple labs and industry partners, all united in a desire to beat COVID-19 as it ravaged the world. While collaboration is a critical foundation for innovation, so too is competition. Ultimately a company wants their drug, their vaccine, their antibody to be the safest and most effective, the better for serving public health and the economy.

We greatly benefited from the sharing of scientific data, genetic sequences, and epidemiological data at a global scale. There are a number of databases and consortiums that played a critical role in serving as a clearinghouse; one example is the international consortium that posted a draft of the genome sequence of SARS-CoV-2 on an open-access site, virological.com, and GenBank. That post helped to accelerate the development of the vaccines. From these lessons, we know that an ongoing challenge we face is the need to ensure that more types of scientific data be required to be made available in a way that meets FAIR Principles - GO FAIR (go-fair.org). This is especially pertinent to industry where stricter controls on data and material availability may not meet the academic and scholarly community's requirement for transparent reporting to support reproducibility.

Sudip Parikh, AAAS, Response to Question Submitted by Representative Jim Baird Q4. Animal research that follows strict ethical guidelines is critical to the ability of science to advance clinical research to support public health. The normal sequence for basic research to advance therapies and treatments for humans typically follows a series of studies that first involve research in cells, then small animals, and when necessary, non-human primates. The same is true for research on the SARS-CoV-2 virus, which included both the development of a mouse model and research involving non-human primates. The need for such research is ongoing, and there is still a demand for better animal models that allow us to study the long-term impacts of COVID-19.

Sincerely,

Sudip S. Parikh
Chief Executive Officer and Executive Publisher, *Science* Journals
American Association for the Advancement of Science

Responses by Dr. Christopher Keane

U.S. House of Representatives Committee on Science, Space, and Technology

"Building Back the U.S. Research Enterprise: COVID Impacts and Recovery"

Questions for the Record to:
Dr. Christopher Keane
Vice President for Research
Washington State University
Submitted by Representative Mikie Sherrill

1. We have heard of difficulties in recruiting and retaining qualified clinical research personnel. The pandemic has certainly highlighted the need for these individuals as clinical research has led directly to the treatments and vaccines we are deploying to help end the pandemic. Is there an opportunity for the Federal Government to invest in these professions to ensure a robust clinical research apparatus remains post-pandemic?

Thank you for this question. Investment in clinical research professions is paramount to the development and testing of treatments and vaccines needed to help end the pandemic, as well as to address a myriad of other related diseases, many of which have been exacerbated by the pandemic. To maximize existing structures, investment should focus on supports for early career researchers to ensure a continued pipeline of clinical researchers. We therefore encourage enhanced support of the National Institutes of Health (NIH) training grant opportunities. These include:

- Career Development Awards (K series): K awards for career development throughout an academic's career. Special mention of the K99 award mechanism in which a junior researcher is provided with funds that travel with them from a post-doctoral experience to a faculty experience are also very successful in helping universities afford to attract the best qualified candidates to faculty positions.
- Research Training and Fellowships (T & F series)
- The NIH loan repayment program: These are a set of programs established by Congress and designed to recruit and retain highly qualified health professionals into biomedical or biobehavioral research careers. The escalating costs of advanced education and training in medicine and clinical specialties are forcing some scientists to abandon their research careers for higher-paying private industry or private practice careers. The LRP program reduces or forgives student loans, allowing researchers to stay engaged in research and not discard it for the more profitable aspects of clinical activity.

Increasing funds devoted to these programs across institutes will result in an enhanced group of research leaders to ensure a robust clinical research structure remains post-pandemic.

A focus on investing in clinical research professions also represents a key opportunity to increase the diversity of the clinical research workforce by investing in The UNITE Initiative: Charging Forward on the Road to Racial Equity in the Biomedical Workforce | SWD at NIH, a NIH-wide effort committed to ending racial inequities across the biomedical research enterprise. An investment in this NIH effort will help the nation grow and retain a diverse clinical research workforce, a crucial commitment to ensure a robust clinical research structure remains post-pandemic.

Lastly, empowering state-funded universities to 1) grow their faculty pool amidst economic recessions, 2) pay competitive salaries to enhance retention, and 3) offer federally supported programs for childcare and eldercare economic assistance will help institutions recruit and retain qualified clinical research personnel. These often pose the biggest barriers for institutions to recruit and retain clinical

researchers, and during and post-pandemic, these will be an even greater need for federal support for these necessary structures to remain in place.

2. Another area where we have seen significant advances specific to COVID clinical research is artificial intelligence. I've heard from experts back in New Jersey that artificial intelligence was a major factor in helping quickly and safely facilitate some of the clinical research related to COVID vaccines. Is there a lesson learned here, not just from artificial intelligence but from all of the improved research processes that have helped speed COVID-related products to market? Have there been changes in how we do research that could help keep American innovators at the forefront post-COVID?

Artificial Intelligence (AI) has indeed played a major role in all phases of the world vaccination effort, including vaccine development, clinical trials, and delivery to the public. This extensive use of AI is just one example of the importance of maintaining – and indeed expanding – investments in fundamental research.

The rapid development of COVID-19 vaccines was made possible by previous investments in biomedical research, artificial intelligence, advanced computing, and other technologies. A key example of these enabling capabilities was the development of genome mapping, or "sequencing," over twenty years ago, and the recent applications of modern sequencing technologies and AI to vaccine development. COVID-19 vaccines have been developed by essentially examining the genetic "map" of the virus provided by modern sequencing techniques, and then using AI, advanced computing, and other techniques to identify which parts, or specific proteins, of the virus the human immune system is most likely to recognize. The vaccine is then developed in a way to trigger a human immune response focused on these proteins – in the case of SARS-CoV-2, the "spike" protein.

The Human Genome Project (HGP), an approximately 13 year, $3 billion effort, produced the first "map" of the human genome in 2003. Progress in AI and other technologies have now reduced the cost and time for mapping a specific genome to less than $1,000 and a few days, even just a few hours in some cases. This rate of reduction is much faster than Moore's Law.

This sustained progress in sequencing technology has enabled the extraordinarily rapid development of COVID-19 vaccines. The first sequencing of the SARS-CoV-2 virus was posted by Chinese researchers on January 10, 2020. Since then, approximately one million sequences or related pieces of data have been uploaded into a global repository hosted by the Global Initiative on Sharing All Influenza Data (GISAID). This world-wide open sharing of data has also been essential to the prompt development of COVID-19 vaccines, highlighting the importance of international scientific collaboration.

AI's contributions beyond vaccine development include facilitating effective clinical trials and analysis of clinical trials data, and vaccine delivery. In particular, AI is being used to facilitate site selection for clinical trials, analyze the millions of data points accumulated during these trials, identify key groups for vaccination, forecast vaccine demand, and identify supply chain issues.

The pandemic has highlighted the rapidly emerging role of AI in conducting research. In March 2020, The Allen Institute for AI (AI2) created a machine-readable COVID-19 dataset incorporating published COVID-19 research results. The AI2 developed an initial capability, known as CORD-19, in 10 days. CORD-19 now incorporates over 280,000 scholarly articles. This machine learning capability allows individuals, including researchers to directly ask questions related to COVID-19 and obtain answers based on the results of these 280,000 articles. This is a fascinating demonstration of the power of

AI and machine learning, and a window into the major changes AI will bring to the nation's research enterprise.

Overall, the pandemic has highlighted the following trends vital to sustaining U.S. innovation:

- *Sustained investment in fundamental and applied research:* Sustained investment in research across the full range of disciplines, including the arts and humanities, is necessary to keep the U.S. as the world innovation leader. Research addressing issues facing our society requires an increasingly interdisciplinary approach, and it's not possible to predict research areas where breakthroughs today are needed to address tomorrow's problems.
- *Artificial intelligence:* AI and machine learning, and particularly the ability to rapidly synthesize information and conclusions from thousands to millions of individual data points, publications, and other sources, is revolutionizing how research is conducted.
- *Responsible and secure data sharing, including international collaboration:* Closely linked to the advent of AI is the need for rapid and open sharing of data. This must be done in a way that also appropriately addresses research security concerns.
- *Virtual technologies:* Virtual meeting technologies have enhanced the ability to share information and collaborate, which is essential to addressing today's increasingly multidisciplinary and global research challenges. Virtual tools are now being extended to include remote operation of teaching and research laboratories and other capabilities essential to innovation and training the next generation of researchers.

This answer touches on just some of the emerging trends in research arising from the pandemic. APLU and its member institutions, including WSU, welcome further discussion on this topic with Congress.

References and links to additional information:

1. https://spectrum.ieee.org/artificial-intelligence/medical-ai/what-ai-can-and-cant-do-in-the-race-for-a-coronavirus-vaccine
2. https://www.washingtonpost.com/health/covid-19-artificial-intelligence/2020/10/30/7486db84-1485-11eb-bc10-40b25382f1be_story.html
3. https://www.wsj.com/articles/how-ai-played-a-role-in-pfizers-covid-19-vaccine-rollout-11617313126
4. https://www.fastcompany.com/90611856/pfizer-ceo-reasons-for-fast-covid-19-vaccine-development
5. https://www.frontiersin.org/articles/10.3389/frai.2020.00065/full

U.S. House of Representatives Committee on Science, Space, and Technology

"Building Back the U.S. Research Enterprise: COVID Impacts and Recovery"

Questions for the Record to:
Dr. Christopher Keane
Vice President for Research
Washington State University
Submitted by Representative Anthony Gonzalez

1. I'm very concerned about human capital development here in the U.S. Compared to countries like China and Korea, our development of homegrown talent in STEM education is pretty minimal and now we're facing a further set back because of the pandemic. What are these countries doing differently than the U.S. to encourage more students to embrace and excel in STEM fields?

Demand for a STEM–capable workforce is high and driven in part by international opportunities. As pointed out in the National Science Board Vison 2030 report, demand is only growing because by 2026, jobs requiring science and engineering skills "are predicted to grow by 13% compared with 7% growth in the overall U.S. workforce."[1] Unfortunately, U.S. K-12 mathematics and science test scores are well below those of many other nations and have stagnated in recent years.[2] In addition, the United States ranks below several other nations – such as Singapore Taiwan, and South Korea – in producing high-achieving STEM students.

Numerous studies have indicated that the U.S. must broaden and strengthen STEM education at the K–12 level. School systems must promote elementary grade participation in STEM, raise overall student achievement and reduce performance gaps among demographic groups, encourage high school students to take more rigorous STEM classes, and improve college and career readiness in mathematics and science.

On the higher education level, the Association of Public and Land-Grant Colleges have partnered with over 125 public universities, including Washington State Univeristy, to share data, test new solutions, and scale best practices to improve college access, advance equity, and increase college degrees awarded. As public universities, we are working together to tear down long-standing barriers, eliminate the achievement gap, and prepare students to thrive in the 21st century workforce.

The federal government can continue to be an important partner in supporting STEM education and I am encouraged by legislation introduced by this committee including t*he STEM Opportunities Act, the MSI STEM Achievement Act,* and *the Rural STEM Education Act.*

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[1] National Science Board: Vision 2030 (nsf.gov)
[2] Elementary and Secondary Mathematics and Science Education | NSF - National Science Foundation

2. In your research, have you studied ways to match workforce capacity with workload both in the public and private sectors? Have you conducted any level of what-if analysis to understand how COVID impacts the functions of human resources departments of both government and private organizations?

While I appreciate the Congressman's question, I am not aware of this type of analysis of human resources departments. Perhaps my fellow hearing panelist, Mr. Quaadman from the U.S. Chamber of Commerce, may be better suited to address this question.

U.S. House of Representatives Committee on Science, Space, and Technology

"Building Back the U.S. Research Enterprise: COVID Impacts and Recovery"

Questions for the Record to:
Dr. Christopher Keane
Vice President for Research
Washington State University
Submitted by Representative Michael Waltz

1. If Congress were to fund the $25 billion directed in the *Research Investment to Spark the Economy (RISE) Act* to support the research recovery at federal science agencies and their grant recipients, what additional steps should Congress take to ensure this research is protected from intellectual property theft and academic espionage?

The impact to America's research institutions caused by the pandemic during the last year is without precedent. While the focus on coronavirus-related research as the federal government's priority has been absolutely correct, the pandemic has greatly affected the research enterprise in this country through the closure of campuses and laboratories. Beyond just impacting graduate students, postdocs, principal investigators, and other personnel directly conducting critical research, the pandemic arrived at a time when the nation was already reckoning with a historic threat to its economic and research preeminence in the form of intellectual property theft and academic espionage. As the nation emerges from the insidious grasp the virus has held on us, it is again time to weigh appropriate measures to address the security of research activities at universities across the country. In order to do so, three steps are encouraged in the near future.

First, the federal government and Congress can continue to focus on clear, consistent, and uniform implementation of laws, regulations, and associated policy documents across all of the funding agencies. Universities take seriously the threats of undue foreign influence and are regularly working with federal law enforcement and research agencies to institute best practices to protect federal investments. Progress on consistency across federal agencies is beginning as evidenced by the direction in the recently released National Security Presidential Memorandum 33 to streamline the administrative burden placed on researchers by standardizing processes, definitions, and forms related to research security to the greatest extent practicable. Additional examples of the recent drive for a uniform approach is found in Section 223 of the National Defense Authorization Act for Fiscal Year 2021, which requires all federal agencies to gather similar information on current and pending support as part of the application process for federal funds. However, universities are already seeing the potential for inconsistent and burdensome implementation, as some recent agency guidance (e.g., National Institutes of Health Notice Number NOT-OD-21-073) have combined the mandatory requirements found in Section 223 with suggested practices found in the "Recommended Practices for Strengthening the Security and Integrity of America's Science and Technology Research Enterprise" published by the National Science & Technology Council in January 2021. By focusing on a uniform implementation of the baseline requirements found in Section 223, before adding agency-by-agency elective conditions, more expeditious and effective implementation of the necessary requirements found in the law will be achieved.

Second, the federal government and its agencies should continue to frequently engage with and utilize associations such as the Association of Public and Land-grant Universities (APLU), the Association of American Universities (AAU) and the Council on Government Relations (COGR). By maintaining a strong and open dialogue with groups like these, the federal government may draw on the expertise and pragmatic knowledge surrounding both the capabilities and challenges faced by research universities.

Finally, Congress should consider the authorization of grant funding for the strengthening and upgrade of information security systems at research institutions as part of any contemplated infrastructure spending. Much as the interstate highway system was constructed to provide for the national defense, yet proved a boon to the economic fortunes of the nation as well, Congress should view the strengthening of research institution information systems as a modern opportunity to build a network of hardened information – highway systems that will pay economic dividends through the security of valuable intellectual property. Individual agency mandates to improve security are in their infancy, such as the Cybersecurity Maturity Model Certification program from the Department of Defense. Yet, these requirements frequently remain unfunded mandates. As university budgets are challenged by the pandemic and declining enrollment, congressionally authorized funding could prove the catalyst needed to ensure America protects its intellectual and economic advantage far into the future.

U.S. House of Representatives Committee on Science, Space, and Technology

"Building Back the U.S. Research Enterprise: COVID Impacts and Recovery"

Questions for the Record to:
Dr. Christopher Keane
Vice President for Research
Washington State University
Submitted by Representative Jim Baird

1. How much of the investment in basic research was on behalf of private industry versus universities or national labs?

The National Science Foundation National Center for Science and Engineering Statics (NCSES) tracks U.S. research and development (R&D) expenditures by source of funding, performer, research/development type, and other parameters.

Figure 1 below shows total U.S. R&D expenditures by source of funds. Note the strong increase in business funding over the past twenty years, and the relatively flat profile of federal funding.

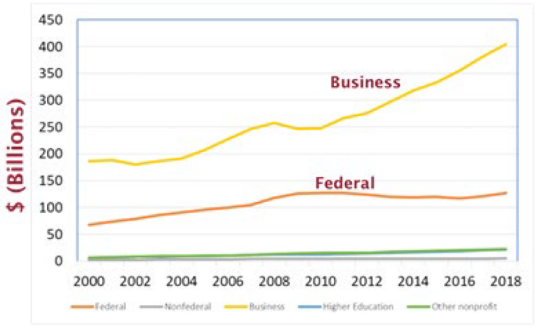

Figure 1: US R&D expenditures by source of funds. (Source: NCSES)

Figure 2 below shows basic, applied, and developmental R&A expenditures for the same time period shown in Figure 1.

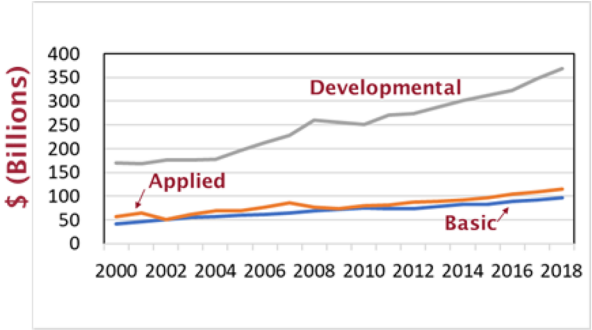

Figure 2: US R&D expenditures by type. (Source: NCSES)

The NSF definitions of basic, applied, and developmental research are as follows:

- *Basic research* is the pursuit of new scientific knowledge or understanding that does not have specific immediate commercial objectives, although it may be in fields of present or potential commercial interest.
- *Applied research* applies the findings of basic research or other existing knowledge toward discovering new scientific knowledge that has specific commercial objectives with respect to new products, services, processes, or methods.
- *Development* is the systematic use of the knowledge or understanding gained from research or practical experience directed toward the production or significant improvement of useful products, services, processes, or methods, including the design and development of prototypes, materials, devices, and systems.

The relative increase in developmental spending shown in Figure 2 reflects the increase in business R&D expenditures, and the fact that the majority of business R&D spending is developmental.

Analysis of the "basic" component in Figure 2 indicates that over the past 5-10 years, the fraction of "basic" research spending is approximately 60% (higher education), 14-17% (federal institutions), 10-15% (Federally Funded Research and Development Centers – FFRDCs), 8-9% (other nonprofits), and 2-5% (business). Note the FFRDC component includes 42 major federally funded laboratories, 17 of which are the Department of Energy national laboratories.

Additional detail on the above is available on request.

Note that data on COVID-related funding for business, higher education, national laboratories, and other performers is not readily available via NCSES or other sources. With that said, partnerships between industry, government, and academia have been critical to fighting the pandemic and developing vaccines. As an example, the government has provided an additional $10.5 billion to industry since the pandemic began. Basic research conducted by industry, academic, and federal laboratories has been the essential ingredient in the rapid development of vaccines. For example, the Moderna vaccine emerged directly out of a partnership between Moderna and Dr. Barney Graham's National Institutes for Health

laboratory while he was at Vanderbilt University. Collaborations involving industry continue to strengthen as we work towards ending the COVID-19 pandemic.

APLU and its member institutions will continue to gather data on COVID-related academic, federal, and industrial research expenditures and provide this information to Congress as it becomes available.

2. Was there basic research that the national labs had already completed that was able to expedite industry's development of the vaccine?

The national laboratories leveraged significant established infrastructure, expertise, research, and partnerships to assist industry in vaccine development and other COVID-19 response activities. Much of the existing research on vaccines and therapeutics was the result of federal investments at the national laboratories in HIV, influenza, and other infectious diseases and leverages Department of Energy investments in high-performance computing and structural biology at light sources. Because the labs do not produce the associated commercial products, there were existing collaborations with industry for technology transition as well as new COVID-specific collaborations. In addition to vaccines and therapeutics, the national labs worked with industry and government agencies to support accelerated manufacturing and diagnostic testing. These activities leveraged established DOE capabilities, as well as historical investments from other agencies.

3. If it was a combined effort between the labs and private industry, do you think that it was a smooth partnership? Was there anything learned that could be improved for future efforts?

Overall lab-industry partnerships went smoothly. The pandemic provided strong motivation for timely action and partnership. It may be useful to identify if there were process or other efficiencies achieved that should be retained. More broadly, the successful COVID-19 response support role provided by the Department of Energy and the labs through the National Virtual Biotechnology Laboratory may be a good model for long-term investment to provide a rapid pivot that links R&D and operations to respond to a national crisis.

4. In my district, we are fortunate to have Purdue University as a leader in STEM education and research. Purdue's Animal Disease Diagnostic Lab is an extremely important resource of innovation and research that serves more than just animals. What is the impact of animal or veterinary laboratories on such research? (mRNA research) Did any research from animal or veterinary laboratories contribute to the development of this vaccine, and in turn, Operation Warp Speed?

The development of mRNA vaccines is the result of decades of fundamental research in structural biology, nucleic acid vaccines, and related topics. The development of mRNA vaccines is thus another example of the importance of long term, sustained commitment to fundamental scientific research.

The mRNA vaccine development effort includes extensive testing in animals. Purdue's Animal Disease Diagnostic Laboratory, the Washington Animal Disease Diagnostic Laboratory (WADDL)

located at WSU Pullman, the WSU Puyallup Research and Extension Center, and similar capabilities thus played a critical (and ongoing) role in vaccine development.

These vaccines were in response to other pathogens, including coronaviruses. While the vaccinations were not fully developed and brought to market, more than 20 years of research with testing DNA vaccines in animals was readily available to the research community to use as a foundation in the development of a vaccination for SARS-CoV-2. The key development for the current mRNA vaccines (Moderna and Pfizer) focused on the liposome-based delivery system, as mRNA is highly labile and getting it into cells intact has been a major challenge. The majority of the research used as the basis for the development of the current mRNA vaccines built on the body of research produced during the past two decades, which was tested on animals at the time the research was conducted. As a result, testing for the current mRNA vaccines could be brought to phase I/II trials in humans without the need to conduct additional animal testing for safety and effectiveness.

The mRNA vaccine also relied on decades of research by Purdue and other researchers on the structure of the coronavirus spike protein. This body of work is being used to this day to study the structure of the spike protein in SARS-CoV-2 variants and understand the effect of virus mutations. Ongoing fundamental research in vaccine stability and manufacturability is also of importance, as is research supporting the "second arm" of virus intervention – antiviral treatments.

In addition to the previous research conducted in Animal Diagnostic Laboratories on a full range of infectious disease intervention, training and skill development is a critical component in the vaccine development enterprise, which ensures the foundation for the next generation of scientists and researchers committed to global health initiatives. A variety of careers are available in basic vaccine research and development, clinical trials, production, and distribution of vaccines to the public. These jobs are available in universities, industry, government laboratories and agencies, hospitals, and on the front line of vaccine distribution all over the world.

Basic and preclinical research focuses on the biochemistry and physical properties that disease-causing microbes use to cause damage to the host. Such research also considers the biophysical characteristics of the microbes that might be used in vaccines or drugs to prevent or interrupt the disease process. A scientist with a doctorate degree leads these studies. However, a wide range of research functions are carried out by research assistants who might require only a Bachelor of Science degree or are students working towards obtaining a doctorate degree. Basic research jobs might also offer opportunities to become an expert at operating specialized laboratory equipment, which can be useful throughout a scientist's career.

Most universities will allow students to volunteer or be paid a small stipend to work in a lab. This provides valuable training and is excellent experience for getting a job after graduation. These student jobs can range from technician assistant, in which the student may be required to prepare chemical stock solutions, wash and sterilize glassware, and care for research animals, to senior technician, who maintains cell line stocks, tracks and breeds research animals, orders laboratory supplies, and may conduct experiments. The invaluable experience these students gain in the Animal Diagnostic Laboratories often create the foundation for these scientists to become virologists or play other important roles in the vaccine development enterprise.

Responses by Dr. Felice J. Levine

AMERICAN EDUCATIONAL RESEARCH ASSOCIATION

April 12, 2021

The Honorable Eddie Bernice Johnson
Chairwoman, Science, Space, and
Technology Committee
U.S. House of Representatives
Washington, DC 20515

The Honorable Frank Lucas
Ranking Member, Science, Space, and
Technology Committee
U.S. House of Representatives
Washington, DC 20515

Dear Chairwoman Johnson and Ranking Member Lucas,

Thank you for the invitation and the opportunity to provide testimony before you and committee members during the February 25 hearing, "Building Back the U.S. Research Enterprise: COVID Impacts and Recovery." I appreciated the opportunity to share some of the initial findings of the research that the American Educational Research Association (AERA) and the Spencer Foundation have undertaken to understand the impact of the COVID-19 pandemic on early career scholars and doctoral students.

I address below responses to the questions submitted for the record by Members of Congress and value their interest in follow-up information. Please do not hesitate to contact me if I can provide additional information.

Representative Mikie Sherrill

Another area where we have seen significant advances specific to COVID clinical research is artificial intelligence. I've heard from experts back in New Jersey that artificial intelligence was a major factor in helping quickly and safely facilitate some of the clinical research related to COVID vaccines. Is there a lesson learned here, not just from artificial intelligence but from all of the improved research processes that have helped speed COVID-related products to market? Have there been changes in how we do research that could help keep American innovators at the forefront post-COVID?

Thank you for your questions. I appreciate your interest in artificial intelligence (AI) and your question regarding research innovations. We see some implications for the use of AI and basic research that led to the development of the COVID-19 vaccines to other scientific disciplines. For example, in education, we are interested in recent comments by National Science Foundation (NSF) and Institute of Education Sciences (IES) officials on a potential partnership to support research in artificial intelligence. Specifically, this partnership and this investment would broaden intelligent tutoring in seeking to provide additional support to students who experienced challenges in educational access and lost in-person learning time since March 2020.

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Advances in the learning sciences, including in AI, and the availability of large-scale data for research, including process data from the National Assessment of Educational Progress, have the potential to structure instruction to meet and adapt to students' individualized circumstances. Ongoing work in the social and behavioral sciences will be important to build capacity in the field to apply computational methods to analyze large-scale data.[1]

In addition, we are aware that artificial intelligence may contribute to discrimination and has the potential to reinforce underlying biases.[2] As the pandemic has exacerbated existing inequities, research in artificial intelligence should be attentive not to further harm groups that have been traditionally marginalized, including people of color, people with intellectual and developmental disabilities, and those facing economic hardship. I noted at the February 25, 2021 hearing that we need to be alert to biased models while embracing opportunities to have diverse scientific teams develop algorithms that capitalize on diverse learning and decision making approaches. I noted as well that doing so could be an internationally competitive advantage for U.S. AI development.

We have also observed during the pandemic how administrators, faculty and teachers, and students adapted to the circumstances created by the public health and institutional measures taken to reduce the spread of COVID-19. There are likely lessons learned that could produce future transformative research and evidence in educational technology that can inform educational practice even as in-person instruction resumes.

Representative Anthony Gonzalez

I'm very concerned about human capital development here in the US. Compared to countries like China and Korea, our development of homegrown talent in STEM education is pretty minimal and now we're facing a further set back because of the pandemic. What are these countries doing differently than the US to encourage more students to embrace and excel in STEM fields?

Thank you for your question. We recognize that data from international assessments show gaps in student proficiency between China and the United States in STEM subject in high school. According to data from the 2018 Programme for International Student Assessment (PISA), several regions of China that participate in PISA were among the top five ranked in math scores among 15-year-olds, while the United States ranked 36th. In science, the U.S.is ranked 18th, which the Beijing, Shanghai, Jiangsu and Zhejiang

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[1] A collaborative project between the University of Michigan and Georgetown University, The Future of Quantitative Research in Social Science, is one example of this work. Researchers from the social science and data science fields are drawing from both fields to build appropriate methodologies to study social media data. Additional information available at http://smrconverge.org/.
[2] See https://www.nytimes.com/2019/11/19/technology/artificial-intelligence-bias.html and https://www.brookings.edu/blog/the-avenue/2019/09/26/ai-is-coming-to-schools-and-if-were-not-careful-so-will-its-biases/.

regions ranking first.[3] Education research can be used to build interventions and professional development to support teachers and students in K-12 to improve STEM academic outcomes.

There are several actions that federal science agencies could be encouraged to take to develop STEM talent in the United States, some of which build upon ongoing work at the National Science Foundation and other federal agencies. Key is recruiting and training a diverse STEM teacher workforce, with strong research interests. Attention to the teaching workforce can have a major impact on building interest in STEM for populations that have been traditionally underrepresented in the STEM workforce. NSF programs, such as the Robert Noyce Teacher Scholarship Program and NSF INCLUDES, have made great strides in diversifying the STEM teaching and research workforce, respectively. A second key area is providing additional resources to Historically Black Colleges and Universities, Hispanic Serving Institutions and Tribal Colleges and Universities to support scientific research at both the undergraduate and graduate levels and to support the engagement of faculty in research. Also, a priority is ramped up support for the broader number of places in which STEM education occurs, *to wit* informal STEM programs that can engage children and youth in STEM.

As indicated in the AERA/Spencer Foundation Voices from the Field report[4] and in my testimony and as noted in your question, the pandemic has resulted in disruption to the development of STEM workforce talent. Some actions that institutions can take but would benefit from investment at the federal level include providing childcare and elderly care stipends for STEM researchers with caregiving responsibilities, expanding the availability of release time, supporting graduate students and early career scholars who experienced disruptions to their work due to the pandemic with bridge funding, and encouraging evidence-based mentorship practices.

Representative Jim Baird

Thank you for your questions; I take them below in turn.

1. How much of the investment in basic research was on behalf of private industry versus universities or national labs?

I will respond to the broader investment in basic research. According to data from the National Center for Science Engineering Statistics,[5] in FY 2019, the federal investment in basic research totaled $39.7 billion, with nearly $3.4 billion allocated to private industry and $578.7 million to industry-administered Federally Funded Research and

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[3] Schleicher, A. (2019). PISA 2018: Insights and Interpretations. *OECD Publishing.* https://www.oecd.org/pisa/PISA%202018%20Insights%20and%20Interpretations%20FINAL%20PDF.pdf

[4] Levine, F. J., Nasir, N. S., Rios-Aguilar, C., Gildersleeve, R. E., Rosich, K. J., Bang, M., Bell, N. E., & Holsapple, M. A. (2021). *Voices from the field: The impact of COVID-19 on early career scholars and doctoral students* [Focus group study report]. American Educational Research Association; Spencer Foundation. https://doi.org/10.3102/aera20211

[5] https://ncsesdata.nsf.gov/fedfunds/2018/html/ffs18-dt-tab028.html

Data Centers (FFRDC). Federal funding totaled $18.5 billion for colleges and universities and $4 billion for university-administered FFDRCs. Non-profit institutions received nearly $3.9 billion in federal funding.

2. Was there basic research that the national labs had already completed that was able to expedite industry's development of the vaccine?

I would defer response to this question to my colleagues who also served as witnesses regarding vaccine development. To respond on applications to non-medical research, the federal investment in education research at the National Science Foundation has led to further development in applied settings. This important support for basic research is supplemented by foundations, internal funding provided within institutions of higher education, and state and local funding. As one additional example, the Small Business Innovation Research program in the Institute of Education Sciences has also encouraged business partnerships and commercialization of educational technology platforms that teachers have used teachers throughout the pandemic. Several of the SBIR projects received initial support for development and piloting in classrooms through IES and NSF research grants.[6]

3. If it was a combined effort between the labs and private industry, do you think that it was a smooth partnership? Was there anything learned that could be improved for future efforts?

On the COVID-19 vaccines, I would defer to the expertise of colleagues in the biomedical sciences. I will add as a general observation that the mRNA COVID-19 vaccines that have been approved for use are the result of accumulated knowledge due to the investment in basic research and draw upon work to develop vaccines for previous viruses (e.g., SARS and MERS). The development of the COVID-19 vaccines could serve as examples for other pressing societal needs, including addressing the impact of lost instructional time on academic outcomes and socioemotional needs of students. The general message that addressing the crises of the day requires investment in science over long spans of time is perhaps the most profound of messages that can be learned.

4. In my district, we are fortunate to have Purdue University as a leader in STEM education and research. Purdue's Animal Disease Diagnostic Lab is an extremely important resource of innovation and research that serves more than just animals. What is the impact of animal or veterinary laboratories on such research? (mRNA research)

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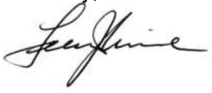
[6]Several educational technology platforms in science, such as ChemVLab+, codeSpark, Physics Playground, and Seeds of STEM, have benefitted from IES and NSF funding through research grants and SBIR grants. A compendium of programs is available from the Science and Engineering Education Network: https://www.readynowsci.org/

Did any research from animal or veterinary laboratories contribute to the development of this vaccine, and in turn, Operation Warp Speed?

We greatly appreciate the research and work that the Indiana Animal Disease Diagnostic Laboratory has undertaken at Purdue to test and trace COVID-19 variants. We acknowledge the impact that animal research has had to inform public health, and that includes the development of the COVID-19 vaccine. I defer to colleagues in the biomedical field to highlight specific examples of research from animal or veterinary laboratories that contributed to COVID-19 vaccines and treatments as they have the more appropriate expertise.

I appreciated the opportunity to testify before the Committee and relaying the experiences that graduate students and early career scholars faced during the pandemic. Please do not hesitate to contact me with any additional questions or if there are any resources that could inform he committee's work.

Sincerely,



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Responses by Mr. Thomas Quaadman

House Committee on Science, Space, and Technology
Hearing entitled, *"Building Back the U.S. Research Enterprise: COVID Impacts and Recovery"*
February 25, 2021
Questions for the Record for Mr. Tom Quaadman

Submitted by Representative Mikie Sherrill

1. The COVID-19 pandemic and response have highlighted the lack of diversity in clinical trials and need to ensure that we have diverse, representative data to foster trust and confidence. Recognizing the importance of enhancing clinical trial diversity, last fall, the Food and Drug Administration (FDA) released final guidance titled Enhancing the Diversity of Clinical Trial Populations – Eligibility Criteria, Enrollment Practices, and Trial Designs. While I appreciate the important step forward, additional work is needed to further enhance diversity in clinical trials. How can we design support for R&D so that it will also support more diversity in research, among both investigators and trial participants? What role is there for collaboration with the private sector in establishing amore diverse clinical trial ecosystem?

The COVID-19 pandemic is an acute reminder of the importance of diverse participation in clinical research given the disproportionate acuity experienced by minority populations. According to the Food and Drug Administration (FDA), while Black or African Americans represent 13.4% of the U.S. population, those populations make up only 5% of overall clinical trial participants. The private sector can support inclusive clinical research through intentional clinical trial design. This starts with ensuring that all actors in the clinical trial process – from company executives to clinical trial investigators to the patients themselves – are educated about the importance of diverse clinical research. Additionally, companies can support inclusive clinical research by identifying where specific disease burden lies and conducting community-level outreach to encourage participation. Through education and targeted community outreach, the private sector can help advance a more diverse clinical trial ecosystem.

2. Having three vaccines now available for US citizens, we see how important R&D is for our public health and safety. However, pipelines for infectious diseases and anti microbial products have at times not been sufficient. How can we work together to explore further use of market-based incentives such as market entry rewards (for reaching a defined milestone, such as bringing a product to market) to support investment and R&D in these critical areas? How can we bring FDA, CMS, NIH, and the CDC into the dialogue to work collectively for thoughtful solutions?

Market-based incentives can have a powerful impact on stimulating the research and development of new therapeutic solutions in previously neglected disease areas. For example, the Orphan Drug Act (ODA), which passed in 1983, provided an additional seven-year period of market exclusivity and a tax credit of up to 50 percent of R&D expenses for new drugs developed to treat orphan diseases. Following the enactment of the ODA, the number of therapeutics approved for rare disease improved dramatically. According to the Food and Drug Administration, new drugs and biologics have been approved for over 900 rare disease indications in the 38 years since the enactment of ODA. The U.S. business community would

welcome a dialogue with the U.S. government on the use of similar market-based incentives for infectious diseases and anti-microbial products.

3. We have heard of difficulties in recruiting and retaining qualified clinical research personnel. The pandemic has certainly highlighted the need for these individuals as clinical research has led directly to the treatments and vaccines we are deploying to help end the pandemic. Is there an opportunity for the Federal Government to invest in these professions to ensure a robust clinical research apparatus remains post-pandemic?

The COVID-19 pandemic has highlighted the importance of public-private partnership in the clinical research process. Multiple effective therapeutics and vaccines were developed to combat COVID-19 in record time as a result of the unprecedented collaboration with the U.S. government. The U.S. business community is supportive of a continued relationship between the private sector, the federal government, and academic institutions to stimulate investment in clinical research professions to ensure the innovative scientific community is well-prepared for the next major public health threat.

4. Another area where we have seen significant advances specific to COVID clinical research is artificial intelligence. I've heard from experts back in New Jersey that artificial intelligence was a major factor in helping quickly and safely facilitate some of the clinical research related to COVID vaccines. Is there a lesson learned here, not just from artificial intelligence but from all of the improved research processes that have helped speed COVID-related products to market? Have there been changes in how we do research that could help keep American innovators at the forefront post-COVID?

The innovative scientific community accelerated the traditional R&D process in order to rapidly meet the global need for new therapeutics and vaccines to combat COVID-19. The simultaneous clinical testing and manufacturing at-risk helped dramatically expedite the availability of treatments and vaccines, once proven safe and effective in clinical trials. U.S. government support of the accelerated clinical research process – through a long-standing commitment to intellectual property protection, federal funding for some of the COVID-19 vaccines, and advanced purchasing agreements – was critical to the discovery and delivery of effective treatments and vaccines in record time. Continued collaboration on R&D will help ensure that the U.S. remains a leader in the innovative life sciences industry.

Submitted by Representative Bill Foster

1. You mentioned the importance and challenge of providing opportunities for small players in basic research. One of the recent emerging trends has been so-called "cloud-based research" in both biology and chemistry, where individual researchers anywhere on the internet write the specifications for experiments that are performed by robotic automated systems located at centralized facilities with capabilities and scale that no single researcher could afford. Many national labs were created for exactly this reason. Is this a promising area for increasing federal investments, for example at the national labs?

Cloud-based research is an important to facilitate collaboration within academia as well as between industry, academia, and the federal government and our national labs play a critical role in that collaboration. The Department of Energy's 17 national labs are a true powerhouse of scientific and technical expertise that make invaluable contributions to economic and national security, including the Argonne National Laboratory and the Fermi National Accelerator Laboratory. The Chamber strongly supports full funding for our national labs and is open to bolstering the capabilities of our national labs through additional federal investments.

Submitted by Representative Deborah Ross

1. Mr. Quaadman, you mention in your testimony that American investment in clean energy research not only helps us to address the issue of climate change, but that it can benefit the long-term growth opportunity for U.S. businesses, in particular when it comes to developing solutions that we can export to the rest of the world. Can you elaborate on the economic cost of failure to adequately invest in our research enterprise in terms of how that would affect the US clean energy economic landscape?

As was discussed at the hearing, investments in our research enterprise correlate directly and strongly with U.S. economic competitiveness. Moreover, because the clean energy transition will occur on a global scale, failure to invest in research necessary to help American companies lead the transition will result in a missed opportunity. With more than 95 percent of the world's population and 80 percent of purchasing power residing outside of the United States, the race to develop the clean energy technologies of the future presents major job and export opportunities for U.S. businesses. Capitalizing on this opportunity begins with a strong federal research enterprise that works closely with U.S. businesses to ensure we lead the world in pursuit of climate change technology solutions.

Submitted by Ranking Member Frank Lucas

1. Mr. Quaadman: A recent priority of this Committee was the National Artificial Intelligence Initiative Act, which established a comprehensive R&D program to accelerate U.S. leadership in AI, and was included in the FY21 National Defense Authorization Act. The Initiative requires NIST to establish an AI risk management framework to establish common definitions and mechanisms to mitigate risk stemming from AI applications. Can you discuss how the AI risk management framework can accelerate the adoption trustworthy AI and address concerns stemming from AI?

Section 5301(c) of the FY21 National Defense Authorization Act directs NIST to develop a voluntary risk management framework for trustworthy AI systems no later than two years after enactment. The Chamber strongly supports the creation of a risk management framework and appreciates this Committee's leadership last Congress to include this provision in the NDAA. We believe that the risk management framework would enable the adoption of trustworthy AI for several reasons. First, there is a lack of consensus on common definitions that would underlie the responsible governance of AI applications including on bias and fairness. The framework is

intended to establish those common definitions so that stakeholders can begin to develop a consensus approach on how to address concerns pertaining to bias, fairness, transparency, etc.. Second, the framework will provide clarity to industry stakeholders so they can align their approaches to AI governance with the framework and thus create a common understanding on important aspects of trustworthy AI. Third, the framework will serve as a model internationally for other jurisdictions to facilitate international cooperation on AI and position the United States as a leader in trustworthy AI.

2. Mr. Quaadman: The National Institute of Standards and Technology (NIST) operates the Facial Recognition Vendor Test (FRVT) to test the accuracy of facial recognition technologies. Can you highlight the importance of FRVT to the private sector and describe how the program can better utilized to address concerns stemming from facial recognition technology?

The National Institute of Standards and Technology's (NIST) Face Recognition Vendor Test (FRVT) enables the private sector developers of facial recognition technology to submit their algorithms for evaluation by NIST. In 2020, 105 developers submitted 140 different face recognition algorithms for evaluation. These evaluations allow developers to improve the performance of their algorithms and thus improve facial recognition technology products. Moreover, testing and evaluation of face recognition algorithms allows the private sector to work to mitigate demographic differentials in those algorithms and thus address algorithmic bias concerns stemming from the application. The Chamber encourages the Committee to support and strengthen the FRVT through codifying the program in statute; strengthening the capabilities of FRVT including through utilizing cloud-based products; and ensure FRVT can effectively serve as the foundation for establishing benchmarks and voluntary, industry-led standards for facial recognition technology.

Submitted by Representative Randy Weber

1. Mr. Quaadman: In your written testimony you say "The Energy Act of 2020 is exactly the "kitchen sink" approach to climate technology solutions the national needs" and that it "presents a major long-term growth opportunity for U.S. businesses." Can you please expand and discuss how these investments in energy technology research will assist in the economic recovery from the pandemic?

While technological research is well understood as a long-term drive of economic growth, its potential contributions to short-term economic recovery are less appreciated. Funding for the Energy Act of 2020 will indeed contribute to pandemic-related recovery. In addition to jobs and opportunity created by increased investment in traditional research activities, the legislation authorizes at least 20 demonstration projects in a broad array of technology areas. Typically funded at levels into the tens of millions of dollars, these demonstration projects—in areas such as carbon capture utilization and sequestration, energy storage research, and advanced nuclear—will provide significant infusions and economic opportunities into the local economies where they are established.

2. Mr. Quaadman: Throughout the COVID Pandemic, a number of supply chain challenges have come to light, including our heavy reliance on China for critical materials and the need for the U.S. to strengthen the resiliency of semiconductor supply chains. Currently the United States is facing significant semiconductor shortages, which has led to significant production cuts in a number of sectors including the auto industry and consumer electronics. How can the timely implementation of the CHIPS for America Act help address the supply challenges in the semiconductor sector and mitigate supply chain risk in the future?

To ensure a resilient supply chain of trusted and assured semiconductors, Sections 9902, 9903, and 9906 of the William M (Mac) Thornberry National Defense Authorization Act for Fiscal Year 2021 (FY21 NDAA) should be fully funded. Sections 9902 and 9903 are based on the CHIPS for America Act and would establish funds within the Department of Commerce and the Department of Defense (DoD) to onshore the design and manufacturing of semiconductors and to provide critical research, development, prototyping and packaging support for these efforts. While these incentives were authorized in the FY21 NDAA, no appropriations were provided to allow for their execution. These semiconductor incentive programs should be funded in this year's appropriation cycle to begin the process of establishing a domestic trusted and assured semiconductor manufacturing base. Not only will developing a secure supply of semiconductors in the United State address national security concerns, but it will also create highly skilled jobs and encourage the development of a domestic supply chain to support design and manufacturing activities.

3. Mr. Quaadman: Part of enabling good research is having government be able to provide data to solve problems like COVID-19. What are some steps that Congress can do here to help, including in the arena of IT Modernization?

It is critical that policymakers develop ways for government and the private sector to collaborate on challenges such as COVID-19. For example the federal government and other private-sector stakeholders are currently participating in the COVID-19 Open Data Research initiative.

In 2019, Congress took a crucial step to address these barriers through the enactment of the Foundations for Evidence-Based Policymaking Act, which included in the OPEN Government Data Act as Title II of the legislation. The OPEN Government Data Act primarily requires federal agencies to identify and publish their datasets in a machine-readable format. Federal agencies should continue existing efforts to increase data quality and availability by ensuring that datasets are accessible in a structured, commonly used, and machine-readable format. This includes the further implementation of the OPEN Government Data Act.

At the same time, Congress has a long way to go in modernization federal and state information technology systems. Currently many agencies continue to operate on 1950s mainframes. In order to meet 21st century challenges, government needs modernize information technology systems to share and analyze data in real time in a manner that is secure and protects privacy. Health agencies are still using paper tracking during the pandemic. On a federal level, for example, the Small Business Admin¬istration's loan processing system crashed twice in April. States have also been plagued with problems stemming from archaic data systems. For example:

- Connecticut's website was unable to handle more than 8,300 unemployment benefits applications, "a fraction of the applications coming in"
- New Jersey had to put out a request for volunteers who know programming language from the 1950s that runs the state's employee benefits system
- In the District of Columbia, it took weeks to remove outdated programming language that held up distributing unemployment benefits.

Although the $1 billion provided for the Technology Modernization Fund in the American Rescue Plan is a step in the right direction, Congress should appropriate further funding to transform the types of technology government agencies rely upon to those such as cloud computing, state of the art data centers, artificial intelligence, and an enhanced private sector-led communications infrastructure that connects all Americans. A long-term and not a piecemeal year-by-year approach is necessary for the IT modernization moonshot needed to help government agencies tackle 21st century public health, employment, and security challenges. Congress should significantly expand IT modernization capital funds and the Technology Modernization Fund instituted by the MGT Act.

Funding alone will not address the government IT modernization gap. Policymakers must facilitate a coordinated plan to ensure that agencies not only utilize resources efficiently but also develop and implement strategic planning around how government IT is procured and integrated into federal operations. Increased collaboration between the private sector and government will be necessary to address emerging needs. Additionally, federal agencies should consider whether commercial off-the-shelf products better equip them as opposed to department-specific solutions. While the efforts of Congress in the past have been laudable, it's time for the federal government to adopt a forward-looking national IT modernization plan that makes the nation more resilient against future crises.

Submitted by Representative Anthony Gonzalez

1. I'm very concerned about human capital development here in the US. Compared to countries like China and Korea, our development of homegrown talent in STEM education is pretty minimal and now we're facing a further set back because of the pandemic. What are these countries doing differently than the US to encourage more students to embrace and excel in STEM fields?

In 2005, the National Academies of Sciences and Engineering and the Institute of Medicine released "Rising Above the Gathering Storm" which rang the alarm bells saying American students were academically behind in STEM education. That same year, U.S. 8th graders were ranked 12th in math and science skills according The International Math and Science Study (TIMMS), behind countries like Singapore, Japan, South Korea, Taiwan. This led to a series of high-profile actions on the part of the United States to focus on STEM education. First, America Competes was enacted, increasing funding for STEM education and research. In 2013, the internationally benchmarked Next Generation Science Standards were introduced which now influence curriculum used in a majority of classrooms. In 2015, the Every Student Succeeds Act was passed which included increased funding for k-12 STEM education among other things.

From 2015 to 2018, according to OECD's Programme for International Student Assessment (PISA), US students improved their international standing in math and science from 35th to 30th and 17th to 11th respectively, suggesting we're moving in the right direction.

Despite the needed attention and some progress, the most recent data reported by UNESCO reveals that India produced almost 2.7 million STEM graduates in 2018. While they did not publish data for China, the World Economic Forum in 2016 reported China produced 4.7 million STEM graduates a year (however there is some question as to how China classifies STEM fields which calls into question the ability to compare). The U.S. produced approximately 550,000 STEM undergraduate and graduate degrees.

In 2019, the OECD issued "Measuring Innovation in Education 2019", looking into how OECD nations compare when it comes to K-12 policy and practice. Certainly building a STEM pipeline begins in our k-12 system. The report compared countries in a variety of areas such as: use of computers when learning math, math homework, science experiments, and incentives to recruit and retain STEM teachers for. Analysis has led some to conclude that U.S. policies and practices don't appear different than other OECD countries and for those high-performing STEM countries, there doesn't appear they are employing any distinctive practices.

However, it's clear in places like China, their swift action on STEM is driven by government policy and investment. For example, their rate of increase in research investment is 18% compared to 4% in the US. In addition, they are laser focused on enrolling students in STEM fields at the undergraduate and graduate level – many in US universities. For example, China has enrolled over 19,000 computer science students in US graduate schools compared to 12,000 US students in those same schools. The US continues to have many of the world's most prestigious universities that focus on STEM. However, U.S. News and World Report rates six Chinese engineering schools in the top ten versus three American. Tsinghua University in Beijing is rated #1.

Submitted by Representative Michael Waltz

1. Mr. Quaadman: In your written testimony, you state that "the strength of the U.S. patent system is a key driver of private sector investment in R&D and a fundamental underpinning for America's competitive advantage in innovation." I agree and that is why we must continue to carry on the work the Trump administration in combating intellectual property theft by China. Much like the COVID pandemic, this unlawful theft is weakening our research enterprise. I would appreciate it if you would share any recommendations you have, including how we can build off of the work of the Trump administration.

The Chamber continues to call attention to China's use of market access restrictions, administrative practices, and cyber-espionage to forcibly acquire sensitive IP. These include innovation and market access-limiting data localization mandates and data transfer restrictions through policies that expressly require IP, innovations, technology, or other data to stay in-country; or that impose unreasonable conditions on sending IP, innovations, or other data abroad or prohibit such transfers outright.

In China, data localization serves as a tool of industrial policy and for supporting local champions, including measures designed to implement the Cybersecurity Law (CSL), which authorizes the Chinese state to prevent U.S. innovators and IP holders from transferring their proprietary information out of China, if the information is deemed to be "important", "sensitive", or "critical." The Chamber sees a need for structural reforms that increase judicial autonomy and protect companies against the unfair State-led manipulation of China's court system, and notes that China's regulatory environment emphasizes industrial policy outcomes that raise the costs, risks, and uncertainties for U.S. companies in China. Over the past year, Chinese central government agencies have made a concerted effort to erect a legal and regulatory framework to advance the senior leadership's objective to create national—and even global—champions with cutting-edge technology and IP in key industries. Two recent U.S. Chamber reports—"Preventing Deglobalization: An Economic and Security Argument for the Free Trade and Investment in ICT" and "Made in China 2025: Global Ambitions Built on Local Protections"—comprehensively document these concerns.

The Cybersecurity Law (CSL), adopted on June 1, 2017, creates a legal framework that may weaken companies' ability to protect IP and other confidential business information (CBI). In addition to broad data residency requirements, the CSL also establishes a framework for security reviews that has potentially intrusive aspects—including the possible required disclosure of source code, algorithms, and other sensitive IP—that may result in U.S. companies being either marginalized from the market or forced to disclose valuable, proprietary information by requiring or pressuring persons to transfer technology in relation to acquisitions, joint ventures, or other investment transactions; imposing administrative and licensing requirements requiring or pressuring persons to transfer technology; requiring or pressuring persons to "use or favor" technologies owned or licensed by domestic persons as a condition for licensing, market access, or receiving benefits; making administrative and licensing requirements and processes transparent; and pressuring or requiring the unnecessary disclosure of sensitive technical information.

2. Mr. Quaadman: in your written testimony you noted that "China, in particular is rapidly investing in research and development, endeavoring to build self-sufficiency in foundational technologies, and achieve absolute dominance in emerging technologies and industries of the future." From your experience, can you speak to China's efforts to achieve this "absolute dominance" through exploitation of American research?

See answer to the question above.

Submitted by Representative Jim Baird

1. How much of the investment in basic research was on behalf of private industry versus universities or national labs?

The private sector makes critical contributions to not just applied and development research, but also basic research. According to the Congressional Research Service, the private sector annually

contributes $28 billion, or 29%, of basic research. The federal government, through national labs, other federal entities, and funding directed at academia, contributes $40.1 billion, or 41.8% of basic research. However, it is important to note that while the federal government funds the plurality of basic research, a significant portion is performed by academia through funding from the federal government. In fact, academia performs $46.6 billion, or 48.3% of basic research.

2. Was there basic research that the national labs had already completed that was able to expedite industry's development of the vaccine?

The expedited development of multiple effective vaccines for COVID-19 was a result of the ongoing partnership between the private sector, academic institutions, venture capital community, and U.S. government. For example, the novel messenger RNA (mRNA) technology used in both the Pfizer-BioNTech and Moderna vaccines dates back to research conducted at the University of Pennsylvania and Harvard Medical School in the 1990s. Backed by venture capital funding, Moderna spent nearly a decade attempting to harness the power of mRNA. Because Moderna was a small start up with no FDA approved medicines, federal government support of the company's research was critical to expediting the clinical research process once it became clear that mRNA could effectively be used against COVID-19 in early 2020. The ongoing partnership between all of the actors in the innovation ecosystem was pivotal to the rapid development of multiple effective vaccines and speaks to the power of public-private partnership as the innovative scientific community prepares for the next global health threat.

3. If it was a combined effort between the labs and private industry, do you think that it was a smooth partnership? Was there anything learned that could be improved for future efforts?

See the answer from the question above.

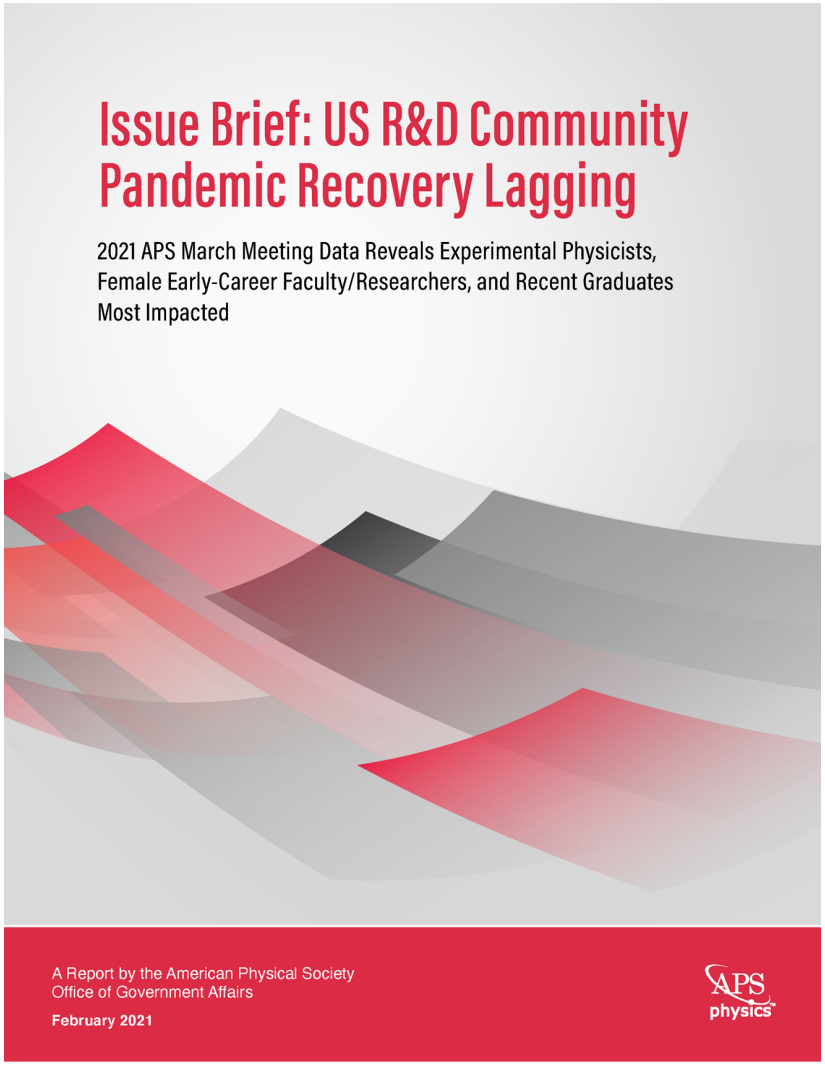
4. In my district, we are fortunate to have Purdue University as a leader in STEM education and research. Purdue's Animal Disease Diagnostic Lab is an extremely important resource of innovation and research that serves more than just animals. What is the impact of animal or veterinary laboratories on such research? (mRNA research) Did any research from animal or veterinary laboratories contribute to the development of this vaccine, and in turn, Operation Warp Speed?

The use of animals in clinical research is an essential component of the drug discovery process. Animals advance our scientific understanding, serve as models to study disease, and help us develop and test potential new medicines and therapies. Given the present state of scientific knowledge, testing potential new medicines and therapies in animals is critical to their evaluation, and is required by regulatory authorities worldwide to ensure the quality, efficacy and safety of the medicines and therapies we develop. Accordingly, the mRNA vaccines utilized data from animal models as part of the application to the U.S. Food and Drug Administration to demonstrate safety and efficacy. The use of data from animals was a critical component of the discovery and approval of safe and effective vaccines for COVID-19 in record time.

Appendix II

Additional Material for the Record

REPORT SUBMITTED BY REPRESENTATIVE EDDIE BERNICE JOHNSON



Overview

The American Physical Society's (APS's) March Meeting is the world's largest physics conference. Hosted annually in the United States, approximately 10,000 research summaries are submitted each Fall by researchers around the world for presentation the following March. These research submissions serve as a proxy for the health of the physics research enterprise. A detailed analysis of this year's submissions reveals a significant reduction in US research output due to the pandemic, with disproportionate impacts on key segments of the US physics community, including women and early-career researchers.

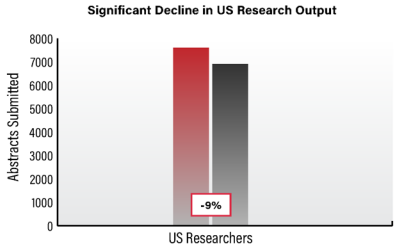
Impacts on Researchers and Their Research Productivity

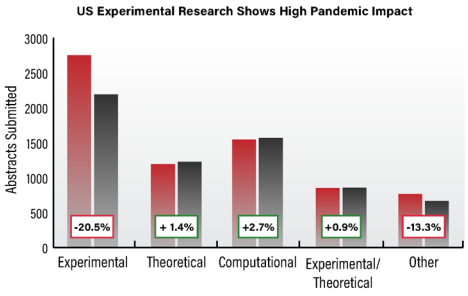
The 2021 March Meeting will be held online with discounted rates compared to previous years, enabling physics researchers worldwide to share their latest work. The meeting continues to see strong global representation, with research summaries – also referred to as "abstracts" – submitted from researchers in more than 75 countries. An analysis of the abstract submitters' information provides several insights on the health of the physics research community:

- Overall US physics research output was significantly reduced from the 2020 March Meeting to the 2021 March Meeting.
- In particular, US experimental physics was severely impacted by the pandemic.
- Researchers at critical career stages are being disproportionately affected.

Reduced US Research Results

Overall, the net number of abstracts submitted to the 2021 March Meeting decreased by approximately 9%.



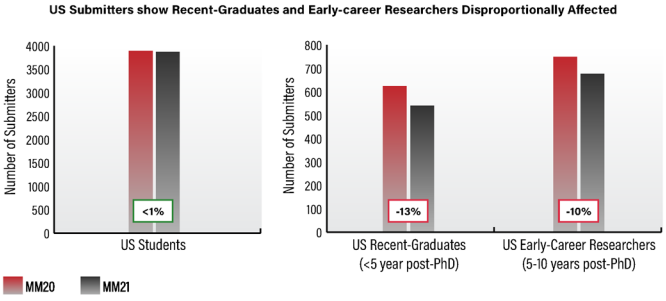


US experimental research shows a dramatic reduction in productivity

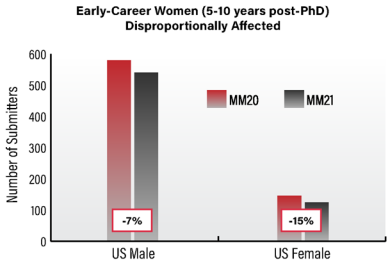
There were 20% fewer US experimental research abstracts in 2021 than in 2020.

Pandemic Impacts US Researchers at Critical Career Stages

Analyzing the US submitters' demographic data reveals that both recent graduates (<5 years since PhD) and early-career faculty/researchers (5-10 years post-PhD) are negatively impacted by the pandemic. Both career-stage groups have a strong career incentive to attend scientific conferences and present their work to advance their careers. However, both groups will have a decreased presence at the 2021 March Meeting. US recent-graduate and early-career faculty/researcher submitters are down -13% and -10%, respectively, from 2020 to 2021.



US female scientists, in particular early-career faculty/researchers who received their PhD between 5 and 10 years prior, have been disproportionately affected by the pandemic. Among the submitters in this career stage, the number of US female submitters decreased by more than -15% – more than double the decrease of their male counterparts (-6.9%).



Policy Responses

The current pandemic has resulted in a severe reduction in our nation's research activity, with many of our universities and national labs experiencing a temporary, but nearly complete, shutdown of research. Our findings compel not only the need for immediate action, but also the need for solutions to address the groups within the R&D community most affected by the pandemic. The following policy actions would address the problems:

- To restore US STEM research capability to a level comparable to our competitors, the US physics community requires immediate research stimulus funding. Partial- or full-cost extensions should be prioritized to experimental physics researchers, as necessary.
- To sustain the front-end of the US STEM workforce pipeline, targeted programs are needed to provide recent PhD graduates and postdocs with opportunities to further develop their independent research skills, while keeping them engaged with the US R&D enterprise. These programs will ensure continuity in their careers and enable them to become more competitive candidates regardless of career choice and even stronger contributors to our nation's research enterprise.
- To sustain US STEM diversity, federal science agencies should enact means for research stimulus funding to be distributed with particular consideration given to researchers who face **family-care demands**, regardless of gender-identity.


APS
physics
American Physical Society • 1 Physics Ellipse • College Park, MD 20740 • U.S.A. • aps.org

LETTER SUBMITTED BY REPRESENTATIVE BILL POSEY

EDDIE BERNICE JOHNSON, Texas
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FRANK D. LUCAS, Oklahoma
RANKING MEMBER

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February 19, 2021

Dear Chairwoman Johnson:

As members of the House Science, Space, and Technology Committee, we respectfully request that our Committee hold a hearing in the next few weeks regarding the science on safely reopening or maintaining our nation's K-12 schools for in-person learning. The purpose of such a hearing would be to provide scientific and factual information to parents, teachers, students, and local school officials about how schools can safely be open during the COVID-19 pandemic, and to consider the research on the detrimental impact on children of prolonged virtual learning.

We appreciate your leadership on the Committee in prioritizing holding hearings regarding the many scientific issues surrounding COVID-19, from the safety of coronavirus vaccines to the impact on the research industry. We can think of no greater issue our Committee should examine than the future of our children, many who are falling behind and struggling with virtual learning.

The scientific community has learned a lot over the past year about the impact of COVID-19 on children, and how to mitigate the spread of the virus. According to an article published in the Journal of the American Medical Association, there is little evidence to show in-person instruction in classrooms contributes to the spread of COVID-19.[1] This study mirrors a report from the European Center for Disease Prevention and Control. The Director of the Centers for Disease Control and Prevention (CDC), Rochelle Walenksy, said, "There is increasing data to suggest that schools can safely reopen and that safe reopening does not suggest that teachers need to be vaccinated."[2]

There is also increasing evidence that virtual learning is having a detrimental impact on the developmental, emotional, and mental health of school-aged children. According to the CDC, mental health emergency room visits increased 24 percent this past March-October over 2019 visits for children ages 5-11, and rose 31 percent for children ages 12-17 over the same

[1] Honein MA, Barrios LC, Brooks JT. Data and Policy to Guide Opening Schools Safely to Limit the Spread of SARS-CoV-2 Infection. JAMA. Published online January 26, 2021.
[2] "Teachers Don't Need Vaccines to Open Schools, CDC Chief Says." *Bloomberg*, 2 Feb. 2021, https://www.bloomberg.com/news/articles/2021-02-03/cdc-director-says-teachers-don-t-need-vaccines-to-reopen-schools

period.[3] This transition to at-home virtual learning has also put a strain on millions of parents and caregivers.

The most recent guidance from CDC released on February 12 makes clear that schools can and should be open.[4] However, there have been conflicting messages from Biden Administration officials, political leaders, and union officials about whether schools should be following the science and prioritizing in-person learning.

We believe a hearing held by our Committee could provide scientific and fact-based information to build confidence for in-person learning. In a recent interview you stated that COVID-19 vaccination distribution is "not an issue that should be tainted with politics," and that decisions "need to be guided by scientific determinations and where those supply is most needed."[5] We couldn't agree more and believe the same about our nation's children and schools.

Thank you for your consideration of this request.

Frank Lucas
Ranking Member
Committee on Science,
Space, and Technology

Randy Weber
Ranking Member
Subcommittee on Energy

Brian Babin, D.D.S.
Ranking Member
Subcommittee on Space
and Aeronautics

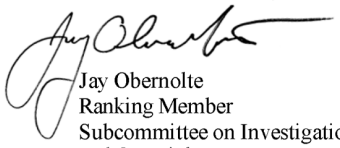
Michael Waltz
Ranking Member
Subcommittee on Research
and Technology

[3] Leeb RT, Bitsko RH, Radhakrishnan L, Martinez P, Njai R, Holland KM. Mental Health -Related Emergency Department Visits Among Children Aged <18 Yeards During the COVID-19 Pandemic – United States, January 2-October 17, 2020. MMWR Morb Mortal Wkly Rep 2020; 69:1675-1680. DOI: http://dx.doi.org/10.15585/mmwr.mm6945a3.

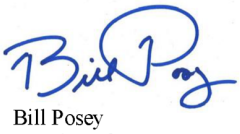
[4] "C.D.C. Draws Up a Blueprint for Reopening Schools." *The New York Times, 12 Feb. 2021,* https://www.nytimes.com/2021/02/12/health/school-reopenings-cdc.html

[5] "House Democrat says the COVID-19 vaccination distribution is 'not an issue that should be tainted with politics." *The Hill,* 21 Jan.2021, https://thehill.com/homenews/house/536228-house-democrat-says-the-covid-19-vaccination-distribution-is-not-an-issue-that?rl=1.

Stephanie Bice
Ranking Member
Subcommittee on Environment

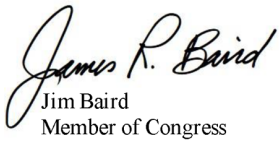


Jay Obernolte
Ranking Member
Subcommittee on Investigations
and Oversight



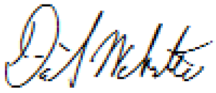
Bill Posey
Member of Congress

Anthony Gonzalez
Member of Congress



Jim Baird
Member of Congress

Pete Sessions
Member of Congress



Daniel Webster
Member of Congress

Young Kim
Member of Congress

Randy Feenstra
Member of Congress

Jake LaTurner
Member of Congress

Peter Meijer
Member of Congress

Carlos A. Gimenez
Member of Congress

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